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J. F. KELLY, Editor

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COMING MEETINGS

ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS

PHILADELPHIA SECTION

Norman C. Bye, Chairman

Linn O. Morrow, Secretary
Schaff Building

LEHIGH NIGHT

SATURDAY, OCTOBER 26, 1929

DR. C. R. RICHARDS, President Lehigh University, Bethlehem, Pa., will talk on "Technical Education"

J. W. BARKER, Professor, Electrical Engineering, Lehigh University, will discuss "Some New Phases of Electrical Engineering," and will also give a brief description of the new Packard Laboratory, which is one of the finest electrical and mechanical laboratories in the world.

N. E. FUNK, Vice President, Philadelphia Electric Company, and a prominent Lehigh Alumnus, will also talk.

AUSTY TATE, Foot Ball Coach of Lehigh University, will also say a few words about Foot Ball Engineering.

Engineers Club,
Dinner at 6:00 P. M. Sharp

1315-1317 Spruce Street,
Meeting at 7:00 P. M. Sharply

CHICAGO SECTION

F. J. Acker, Chairman

A. J. Whitcomb, Secretary

FRIDAY, NOVEMBER 22, 1929

"Internal Combustion Type Locomotives for Steel Plants," by D. C. Hershberger, Railway Engineering Dept., Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

PITTSBURGH SECTION

INSPECTION TRIP

FRIDAY, OCTOBER 25, 1929

Central Alloy Steel Corporation, Massillon, Ohio.
Timken Roller Bearing Company, Canton, Ohio.

Train leaves Pittsburgh, Pennsylvania R. R. Station, 8:05 A.M., E. S. T.

ELECTRIC HEATING AND WELDING CONFERENCE

WEDNESDAY, NOVEMBER 13, 1929

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EDITORIAL

IN LIVING OUR STEEL MILL LIVES WE OFTEN STOP AND PONDER AND OFTIMES WE SEARCH AMONG THE MYSTERIOUS FORCES THAT BURN AND CRUSH AND BEND THE MIGHTY SLABS OF STEEL, FOR A FIGURE THAT WILL TRULY REPRESENT TO US THE SIGNIFICANCE OF OUR MODERN GREAT, POWERFUL INDUSTRY.

WISE MEN, KINGS OF FINANCE, CONQUERORS OF SCIENCE HAVE ALL STOOD HERE BUT ANSWERED NOT OUR QUESTION.

OUR MEMORIES TAKE US BACK AND BACK TO THE DISTANT PAST AND THERE WE SEE THE MODEST FIGURE OF A MAN, SLOWLY, PAINFULLY, LABORING WITH A RUDE FURNACE BUILT OF ROCKS AND FROM IT TRICKLES A SMALL STREAM OF MOLTEN METAL SLOWLY FINDING ITS WAY INTO A SMALL BASIN.

TOWERING NOW BESIDE HIM ARE THE GIANT STRUCTURES OF STEEL AND BRICK WHICH POUR FORTH ITS THOUSANDS OF TONS OF IRON, BUT THIS MODEST MAN PLODS ON.

WE SUDDENLY RECOGNIZE THE FIGURE WE ARE SEEKING. WITHOUT HIM NO STEEL MILLS OF TODAY, NO CRUSHING GRINDING MILLS POUNDING OUT THE SLABS OF STEEL.

THIS FIGURE WE HAVE FOUND IS THE IRON PIONEER. HE PLODDED, HE WORKED AND SOME STRANGE URGE SENT HIM EVER CLIMBING UPWARD, PRESSED HIM ONWARD, HELD OUT NEW VISIONS FOR HIS EAGER EYES TO SEE. THE OLD PIONEER IS GONE, HIS SONS ARE GONE, AND HIS SONS ARE GONE, BUT THEIR SONS ARE YOU AND I, CLIMBING, PLODDING, WORKING.

WE MIGHT HAVE HOISTED OUR ANCHORS AND SAILED OUR BARKS ON NEW SEAS, BUT OUR ADVENTURES ARE NOT AT AN END; OUR EYES, TO SEE NEW VISIONS; OUR JOURNEY HAS JUST BEGUN, THE NEW FIELDS BECKON US TO COME AND CONQUER, FOR WE ARE ALL OF US, STILL PIONEERS.

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*Report of the Electric Heat Committee of the Association of Iron and Steel Electrical Engineers for the Year 1928-29**

By GEORGE H. SCHAEFFER†

The 1929 Electric Heat Report aims to include the developments which have occurred since our 1928 Annual Convention. The report closely follows the previous report in general outline.

Low temperature furnaces are considered to cover all temperatures up to 750° Fah., medium temperature furnaces run up to 1800° Fah., the high temperature furnaces are those above 1800° Fah.

The subject of melting furnaces is given full consideration.

GEORGE H. SCHAEFFER

We have not sub-divided our data, but instead have attempted to give a description of practically every type of furnace introduced to the present time. Operating data relative to these same furnaces is furnished. We have also included a brief description of the Electro Magnetic Hardening Furnaces and the Homo Circulating Air Electric Tempering Furnaces.

We have tried to confine the subject as far as possible to equipment that is particularly interesting to the Steel Mill Engineer.

*Presented before 25th Annual Convention, Association Iron & Steel Electrical Engineer, June 1929.

†Chairman Electric Heat Committee.
George H. Schaeffer, The Carpenter Steel Company.
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Wirt Scott, Westinghouse El. & Mfg. Co., Mansfield, O.

The report represents the co-operative effort of all the members of the Committee.

Special thanks are due to the electrical Manufacturers who have kindly assisted us in every possible manner.

ELECTRO MAGNETIC (HEVI-DUTY) HARDENING FURNACES

General Description

The Hevi-Duty Wild-Barfield Electro-Magnetic Steel Hardening Equipment consists of an electrically heated Furnace, either Horizontal or Vertical, and a Control Panel in electrical connection with it.

The Furnace has a refractory heating chamber surrounded by a closely wound helix of alloy wire, the electrical resistance of which produces the necessary heat. A controlling resistance in the circuit gives a means of regulating the furnace temperature. Superimposed on the main winding is the secondary of indicator winding electrically connected to the Magnetic Indicator on the Control Panel. The whole Furnace unit as above is thoroughly insulated to reduce heat losses to a minimum, and is surrounded by a substantial case of polished aluminum with cast ends.

The Control Panel carries:

(a) The Magnetic Indicator by which a visual indication of the quenching moment is given to the operator.
(b) The Regulating Rheostat for controlling the Furnace Temperature.
(c) The warning lamp of the excess temperature cutout.
(d) A pyrometer for indicating the temperature of the Furnace.

The electrical circuits of the complete equipment are as follows:

F. Is the primary or heating winding on the furnace chamber.
D. Is the secondary or indicator winding on the furnace casing.
S. and P. are the secondary and primary windings of a coil generally designated the compensator.
Mc. Is the moving coil of the magnetic indicator. This has a pointer attached to it which moves over a scale like an ammeter or a voltmeter.
W. Is the winding on an electro-magnet between the poles of which the coil Mc. moves.

Normally an electro-motive force is induced in D, which is opposed and completely neutralized by an equal electro-motive force induced in S.

As soon, however, as a piece of steel is introduced into the furnace, the electro-motive force in D is augmented by the presence of the steel; the electro-motive force opposing it in S is overpowered and a small current circulated through MC., causing it to move on its axis, the pointer generally being deflected fully across the scale against a stop, against which it remains so long as the steel is in the magnetic condition.

When the steel has nearly attained the non-magnetic condition, the pointer leaves the stop and comes slowly down the scale. Finally when the steel has lost its last trace of magnetism and is in exactly the right condition for quenching, the pointer ceases to move. The operator simply charges the furnace with the steel to be hardened and allows heating to continue until the pointer of the magnetic indicator shows when to quench. There is no necessity to arrange the charge in any special way, the furnace being worked exactly like any other furnace.

HOMO CIRCULATING AIR ELECTRIC TEMPERING FURNACES

The Homo furnace for tempering has been designed with the idea of eliminating some of the difficulties found in existing equipment used, principally in the tempering operation of production quantities.

The Homo drawing method is unique in that the transfer of heat from the hearth to the work by radiation has been practically eliminated and the heat is transferred principally by forced convection. The furnace is provided with air passages and there is forced circulation actuated by a fan which is in turn driven by a motor. The motor is automatically reversed at certain intervals. The work is lowered into the inner space in a basket having a perforated bottom. A circulating wall shields the work from the direct radiation of the heating coils. Air is used as the heating medium. The air is circulated by means of a fan located either in the top or bottom of the furnace the direction of the air is changed at frequent intervals as already stated, thus tending to still further break down any further temperature difference between the top and bottom of the load.

The effect of this reversal is very marked, causing a very close uniformity of temperatures. In order to prevent "over shooting" of control temperature in any part of the load, arrangements have been made to automatically reduce the power input to the furnace at a temperature slightly below the desired control temperature. This change in power of the input is accomplished by suitable control discs which attend the necessary relays and generators in the control panel. The effect of thus reducing the input is very appreciable in the consummation of the total KWH.

Trend of Power Costs

Increased refinement in the operation of steam plants still continues. The use of high steam pressures heretofore thought impossible is becoming quite common. Consolidation continues and the number of operating Companies is on the decrease. On the other hand, the total KWH generated is greater than ever before. These features make for a lower power cost.

Aside from the comparison on the BTU basis, there is a growing tendency to evaluate the advantageous features of this new method of steel treatment. This refers to uniformity of product, elimination of waste, cleanliness, choice of location, etc.

No doubt this tendency is due to the knowledge gained by actual operating experience in connection with electric heating equipment. As the installations increase, this tendency to evaluate these advantages will also increase.

As to the trend in the cost of power the curve is still downwards and power costs are still on the decrease.

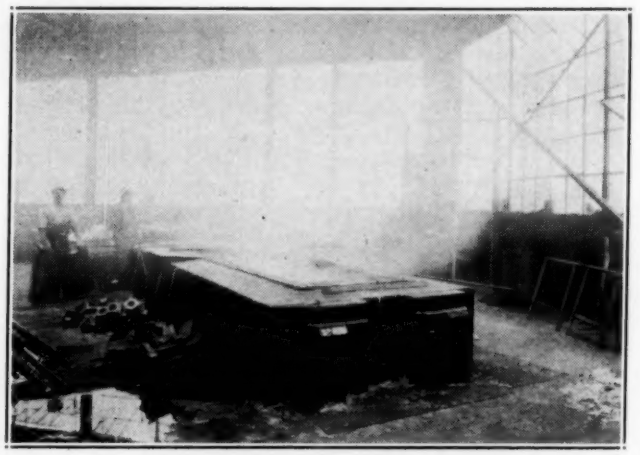

FIG. 2

In the following we have listed the most important types of resistance furnaces and given in detail the application and operating data.

Galvanizing (1200° F. and below)

Each year more interest is being shown in the application of electric heat to galvanizing tanks. Fig. 2 shows an electrically heated galvanizing tank. The inside dimensions of the tank are 3 ft. wide,

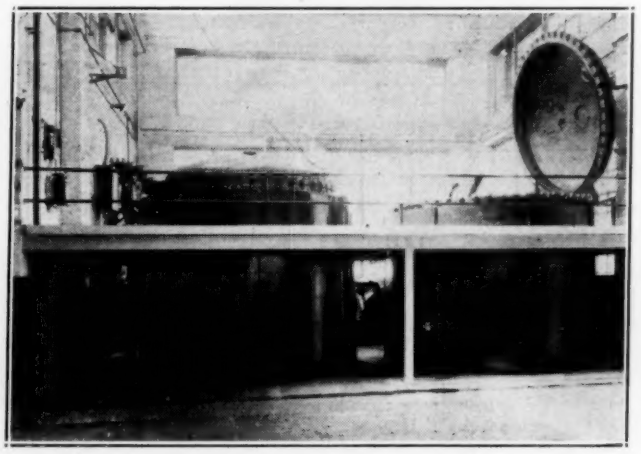

FIG. 3.

15 ft. long and 3 ft. deep and the total connected load is 198 Kw., 220 volts, 3 phase. This tank is capable of galvanizing 3,000 lb. of steel per hour with a power consumption of approximately 122 KWH. per ton of steel galvanized, when operating continuously at a production of 3,000 lb. of steel per hour.

Vacuum Impregnating Tanks

This process is carried out at a temperature of approximately 350 Deg. F. The compounds used carbonize at a temperature slightly above the operating temperature, therefore, it is necessary that the tanks be heated uniformly without overheating at any point.

Fig. 3 shows two electrically heated tanks which replaced two circulating hot oil, gas fired tanks. The tanks shown are 9 ft. in diameter and 26 ft. deep.

The tanks are kept at operating temperature continuously and a large percentage of the heat required is to supply standby losses. The electrically heated tanks gave a saving in fuel alone of over 50%, with electric rate of one cent per KWH. and gas rate of 65c per thousand cu. ft. of 500 B.T.U. per cu. ft.

Vitreous Enameling (1200 to 1850° F.)

In last year's annual report reference was made to a new type of an electrically heated continuous vitreous enameling furnace. This furnace is of the continuous compensating, air sealed "U" type; the heating chamber being elevated above the floor so that the bottom of the heating chamber is above the top of the opening at the entrance end. By elevating the heating chamber in this manner, the heat losses are considerazly reduced.

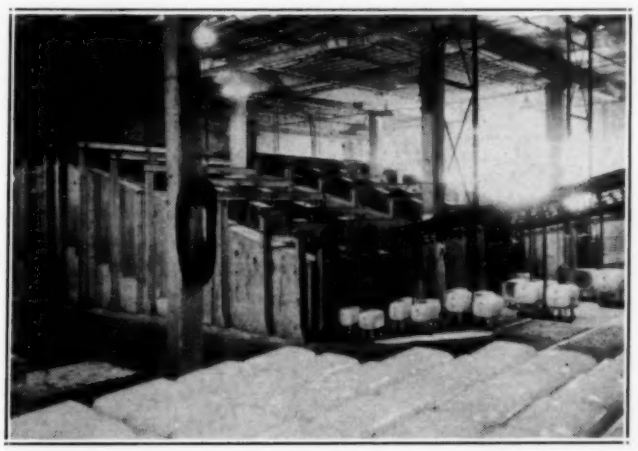

FIG. 4.

Fig. 4 shows this type of furnace.

The economy will vary from 15 to 20 pounds gross per Kwh. Where the hanging tools are light as compared with the work, as in the case of steel sheets, the net economy will approach the gross economy figure given above.

This type of furnace is suitable for firing any type of ware that can be carried through the furnace on a conveyor, such as cast iron and sheet steel, stove parts, kitchen ware, pails, table tops, signs, refrigerator parts, street lighting reflectors, etc.

To date nineteen of these furnace have been installed or are now being installed.

Annealing of Steel Castings

Annealing of steel castings is a process requiring accurate control of the temperature and uniform heat distribution throughout the charge.

The car bottom and elevator type furnaces are the types of furnaces most suitable for this class of work; the car bottom type having the wider application.

Fig. 5 shows a car bottom electric furnace for annealing miscellaneous steel castings. The working dimensions of the furnace are 4 ft. 6 in. wide,

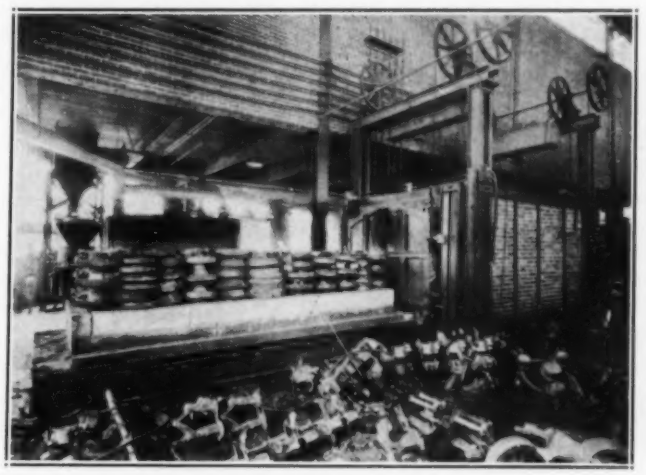

FIG. 5.

12 ft. long and 3 ft. high, and the furnace has a connected load of 240 Kw., 220 volts, 3 phase.

The following data covers two charges annealed in the above furnace; the heating being done during night to take advantage of off peak power rate.

The power is turned on at 4 P. M., and off at 3:30 A. M., or a total of 11½ hours, which includes the heating up and soaking periods. The charge is allowed to cool in the furnace until 4 P. M., when a new charge is placed in the furnace. The furnace and charge cools to about 1250 Deg. F.

Wt. of Charge Pounds	K.W.H. Consumed	K.W.H. Per Ton	Furnace Temp.
22,570	2,640	234	1625 Deg. F.
21,152	2,630	249	1625 Deg. F.

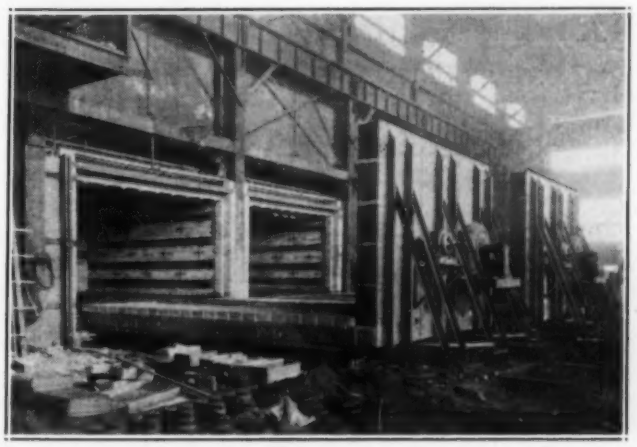

FIG. 6.

Fig. 6 shows two large car bottom furnaces for annealing large steel castings; 50 tons per charge. Each furnace has working dimensions of 15 ft. wide, 20 ft. long and 9 ft. high and is rated 1100 Kw., 440 volts, 3 phase divided into five separate control circuits.

CARBURIZING AND NORMALIZING

An electrically heated box type furnace with a cooling chamber for recuperation is being used by the Cincinnati Milling Machine Company, Cincinnati, Ohio, for Carburizing and Normalizing. The cooling chamber is an independent structure and is installed beside the furnace proper.

It is arranged with two decks, the hot charge being placed on the lower deck, and the cold charge on the upper.

The equipment is operated 24 hours per day and each charge is in the furnace from 8 to 18 hours. At the end of the run, the cooled charge is removed from the lower deck of the cooling chamber and the hot charge from the furnace proper takes its place. The preheated charge is then transferred from the upper deck of the cooling chamber to the furnace. A cold charge is then placed in the upper deck of the cooling chamber. At the end of the heating period of 8-18 hours this cycle is repeated.

Such an installation, due to its flexibility, offers decided advantages over a continuous operating furnace, because it can be used for a large variety of sizes of work in both normalizing and carburizing operations.

The furnace proper is of the box type construction with heating elements mounted on both side walls, in the roof and underneath the cast nickel chromium hearth plate. The elements are so distributed to compensate for door losses and give uniform temperature throughout the furnace chamber. Pyrometic checks showed a maximum difference of temperature in the furnace of 10-15 deg. F., at the normal operating temperature, 1650 deg. F. In the floor of the furnace are installed three nickel chromium channels extending the length of the furnace chamber, on which the charge rests. The prongs of a specially constructed crane are slid into these channels to remove the charge,

The furnace is equipped with the latest protective devices to make the operation safe and fully mechanical. The door is motor operated and has hatchway limit switches which automatically prevent over travel. When the door is opened, an automatic cut-off de-energizes the heating elements. Gold protective fuses are provided which automatically de-energizes the heating elements in case of failure of the automatic control equipment. Automatic temperature control is provided by means of which the temperature is maintained within limits of plus or minus 7.5°F.

The furnace has a working dimension of 6′D. x 4′W. x 33″H.

The cooling chamber is of the box type construction, with special supporting members in the center, capable of supporting the maximum charge. Four rails extending the length of the furnace are provided on both the lower and upper decks to facilitate handling of the charge. Sufficient insulation is provided to reduce the radiation losses to the lowest possible minimum and to make the process of recuperation as thermally efficient as possible.

The doors are motor operated and are equipped with hatchway limit switches which automatically stop the doors at the upper and lower limits of travel. The doors are designed and counterweighted in such a way that the upper half can be raised and lowered independently of the lower half.

To handle the charge efficiently a special crane was designed and built by The Cincinnati Milling Machine Company. This crane has three horizontal prongs which may be raised and lowered along two channels which are rigidly fastened to the carriage. The carriage moves in a horizontal direction and moves the charge in and out of the furnace.

A special feature of the crane is that the prongs are made of L-shaped forgings, the vertical member being adjacent to the vertical channels of the carriage. By reversing the position of the members, the crane can serve an additional furnace facing the first one.

Four trays are used, there being three in the furnace and cooling chamber at any one time. This allows the time of one complete cycle for removing the charge from the fourth tray and reloading.

The furnace has an electrical capacity of 90 K.W. arranged on a balanced 3 phase, 230 volt, 60 cycle circuit. The elements are connected in delta and may be changed to star by means of a knife switch to give a reduced capacity of 30 K.W. during the holding period. This reduction of input increases the accuracy of the temperature control.

The production of the furnace is based on treating a gross charge of 3750 pounds, 750 pounds of which represents the weight of the tray. With the furnace at 1650° F. and a cold load of approximately 3500 pounds gross, the load reaches 1650° F. in 3¾ hours with a power consumption of 340 K.W.H. The furnace is held at 1650° Fah. for six hours requiring a power consumption for the entire cycle of 460 K.W.H.

When the charge has been preheated, a temperature of 600°F. is obtained in the cooling chamber. With the furnace at 1650° F. the load reaches 1650° F. in three hours with a power consumption of 240 K.W.H. The furnace is held at 1650° F. for six hours, requiring a power consumption for the entire cycle of 360 K.W.H.

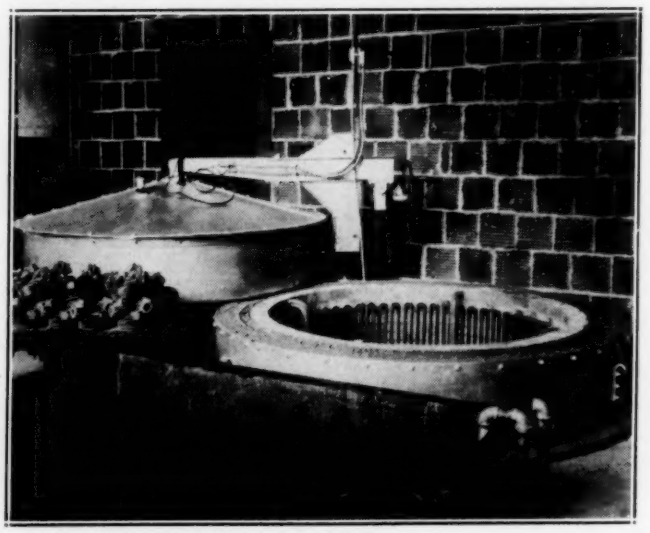

FIG. 7.

The saving effected for each charge by the use of the cooling chamber is 100 K.W.H., or over 20% of the total power consumption. In addition, the cooling chamber affords a means whereby the cool-

ing of the normalizing charge through the critical range may be reduced to a rate which will give the good normalizing. For further control an adjustable damper between the two decks serves as a means of regulating the cooling rate of the normalized steel so that the greatest refinement of grain structure and good machining qualities may be obtained. Without the cooling chamber such charges would have to be cooled in the furnace, with consequent sacrifice of much heat in the furnace walls and further, the loss of the heat gained by recuperation.

PIT TYPE ELECTRIC FURNACE

Fig. 7 shows a 60 K.W. circular pit type electric furnace for heating airplane motor crank cases, cylinder heads and other parts. This furnace accommodates a circular steel basket 55″ in diameter and 60″ deep and has electrical capacity for heating to a temperature of 1000° F., and 300 lbs. of steel basket and 650 lbs. of aluminum in one and one-quarter hours. Actual production and time cycles depend on analysis of the metal being treated.

This furnace is equipped with a two-point recording temperature controller for automatically controlling the temperature of the equipment within plus or minus of 5° C.

"PULL THRU" TYPE FURNACES

Fig. 8 shows two "Pull Thru" type furnaces used for annealing brass tubes installed in the plant of a prominent brass manufacturer.

FIG. 8.

The product put through these furnaces is brass tubes and shells, and the process used is annealing to remove all strains and obtain a definite grain structure.

Special Features:

The work is preheated from room temperature to approximately 800° F. in oil furnaces, and then immediately placed in an electric furnace when the temperature is raised to 1022° F.

There are 2 oil fired furnaces, and 2 electric furnaces. An electric furnace is placed 44″ from the end of an oil furnace, with connecting skids which are covered with insulating materials to prevent the work from cooling appreciably when being taken out of the oil furnace and into the electric furnace.

The tubes or shells are loaded into pans, and the pans drawn into the furnace. Each furnace holds 2 pans, one behind the other. The pans are connected together by a link. As a charge is removed from the furnace, another charge is drawn in.

When withdrawing a charge from the electric furnace, a link about 6 feet long is connected between the last pan in the electric furnace and the first pan in the oil furnace, so that as the charge is removed from the electric furnace, a preheated charge is drawn in at the same time. The cold charge is also drawn into the oil furnace for preheating with the same operation at the entrance end of the oil fired furnace.

ANNEALING FURNACES

Type furnaces:
Stationary hearth, brick and buck stay construction.
Chamber Dimensions:
Length .....18 feet
Width .....5 feet
Height .....30 inches
Electrical Capacity.....130 KW.
Number Control Zones.....2—65 KW. each
Power Supply.....3 phase, 60 cycles, 440 volts
Dimensions of each pan:
Length .....8 feet
Width .....5 feet
Height .....10½ inches
Weight, each pan.....650 pounds
Weight of brass, each pan, ...500 pounds
Lengths of heat treatment.....20 minutes

ROTATING HEARTH FURNACE

Fig. 9 is a rotary hearth furnace for hardening ball bearing races. The speed of the revolving hearth may be varied as required ,to secure thorough saturation of the charge. The exact timing cycle and temperature are predetermined by the

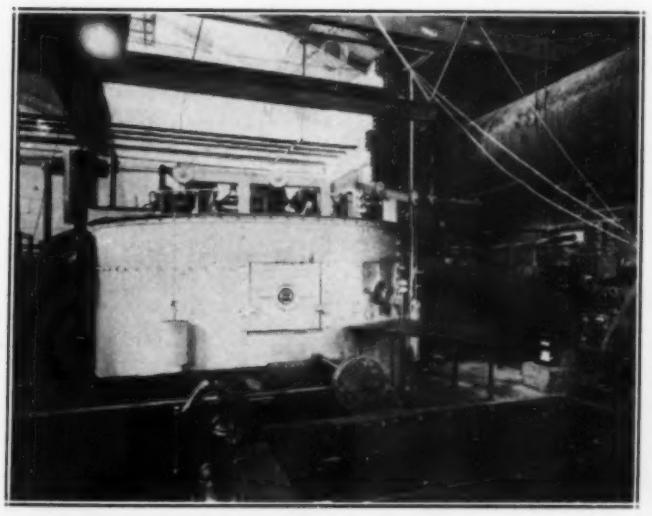

FIG. 9.

metallurgist. The charge is automatically discharged into a quench bath.

Results Learned

Five less men needed in the hardening room.
Men required for inspecting and testing reduced

from three men to one man, due to accuracy of heat treatment.

Uniform high grade results, a test count showed 10,000 consecutive pieces without a single rejection.

ROTARY HEARTH FURNACE—AUTOMATIC DUMPING

Fig. 10 shows Automatic Dumping Type Rotary Hearth Furnaces used for hardening and tempering bolts, nuts and cap screws. The quench chutes are designed so that the load from each tray is evenly distributed into the quench.

Product:

Bolts, nuts, cap screws; ¼" to ⅝" diameter, 1" to 6" long.

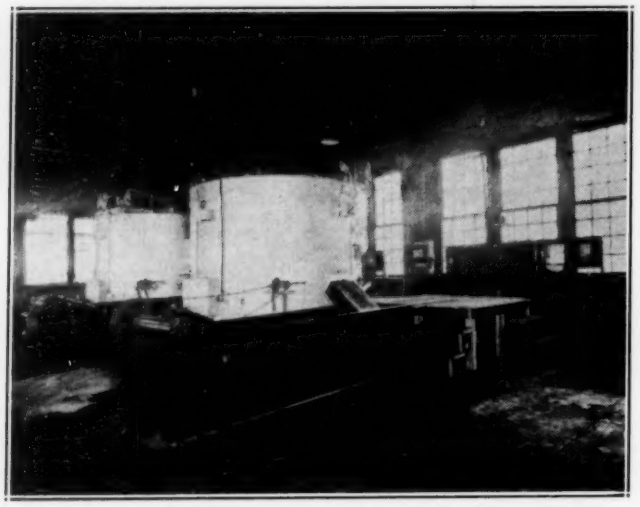

FIG. 10.

Process:

Hardening

Kind of furnace.....Rotary hearth
Mean diameter of hearth.....5 feet
Electrical capacity .....100 KW.
Speed of hearth.....Variable, 1 to 4 per hour
Operating temperature.....1500°-1600° F.
Hearth.....Dumping Type
Quench..... Automatic
Number of furnaces.....Two

Dimensions of quench tank:

Length .....11 feet
Width .....32 inches
Height .....30 inches
Quenching medium .....Water

PUSHER TYPE FURNACES

Fig. 11 shows two pusher type furnaces, one for hardening, one for tempering small axles, spindles, steering knuckles, etc. The speed of the traveling conveyor and the temperature is adjustable, depending upon the weight and kind of product, readily and accurately obtained in accordance with the metallurgical standards set for the various products. Work from the hardening furnace is automatically quenched, conveyed out of the quench tank, and then placed on the conveyor of the tempering furnace, when the heat treatment is automatically completed.

The hardening furnace (to the left) has a capacity of 177 KW, and the tempering furnace 120 KW.

Product:

Axles, spindles, steering knuckles, etc., used by the automobile industry.

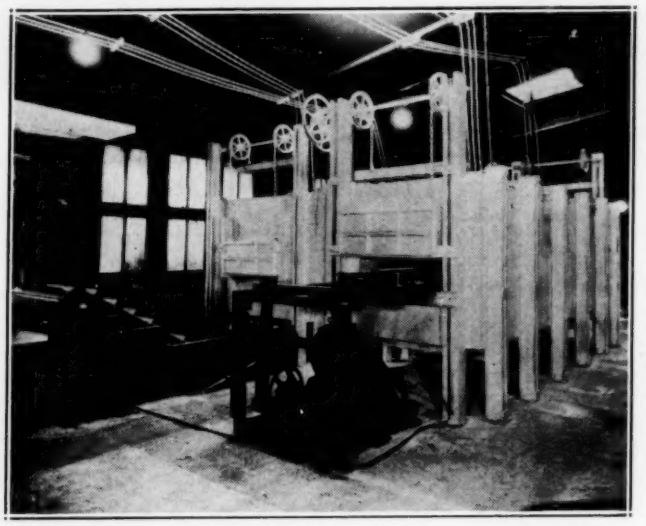

FIG. 11.

Process:

Hardening and tempering.

Weight of axles, specific case.....13 pounds each
Length of heat treatment.....90 minutes

Hardening Furnace

Type of furnace.....Pusher
Chamber dimensions:
Length .....192 inches
Width ..... 44 inches
Height ..... 30 inches
Electrical capacity.....177 KW.
Number control zones.....2
Division of control zones:
Heating zone .....114 KW
Final control zone..... 63 KW
Power supply.....3 phase, 60 cycles, 220 volts
Operating temperature.....1600° F.

Tempering Furnace

Type of furnace.....Pusher
Chamber dimensions:
Length .....168 inches
Width .....44 inches
Height .....30 inches
Electrical capacity .....120 KW
Number control zones.....2
Division of control zones:
Heating zone .....60 KW
Final control zone.....60 KW
Power Supply.....3 phase, 60 cycles, 220 volts
Operating temperature .....1200° F.

CAR TYPE FURNACE

Fig. 12 shows a car type furnace, 5 ft. wide, 25 ft. long, having a connected load of 325 KW. This furnace is used largely for drawing steel bars at temperatures averaging 1200° F.

During the month of March, 1929, over 900,000 lbs. of steel were treated in this furnace with an average power consumption of 230 KWH per ton.

There are now in operation, 25 furnaces of this same general type in the carbon and alloy steel plants, with a total connected load of 6000 KW.

One of the most important developments put into operation during 1928 in this district was the use of accelerated cooling. Previously one of the handicaps of electric furnaces having special annealing cycle was that the furnace cooled very slowly below 1300°. In such cases the operator found it undesirable to remove the work from the furnace until the temperature of 1000 to 1050° was reached, some operators going as low as 800° before removing the work.

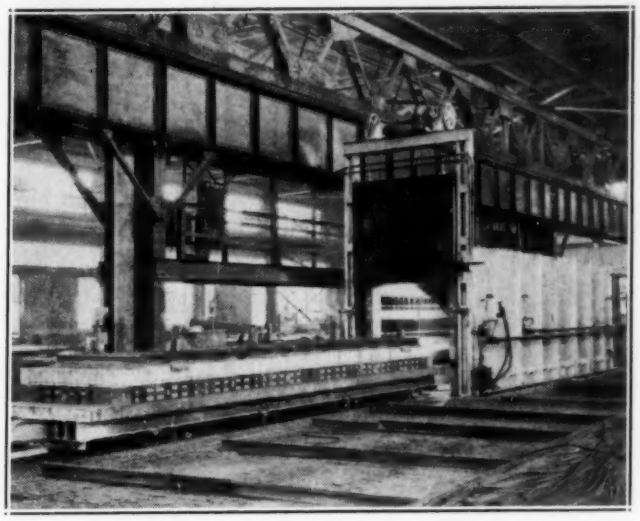

FIG. 12.

Due to the heavy heat insulation necessary for the economical operation of a furnace at high temperature the radiation loss at the lower temperature is very small and therefore cooling below 1300° becomes a slow process. We now have the established practice of building cooling ports into the arch of the furnace, through which air is blown in order to accelerate the cooling rate.

Through the use of this system of accelerated cooling annealing cycles have been shortened as much as 15 hours.5

ELECTRIC STEEL MELTING FURNACE

Arc Furnaces installed during 1928

Number	Tons Capacity	Total Tonnage
1	100	100
1	15	15
1	8	8
3	3	9
4	1½	6
3	1	3
4	½	2
7	¼	1¾
24		144¾

An outstanding application recently announced is the use of the induction furnace for melting high content chromium scrap without appreciable loss of chrome.

The most outstanding electric melting furnace installation for 1928 was a six electrode Heroult furnace, placed in operation about the middle of November. The furnace has been in continuous operation since that time. While no definite tonnage rating has been given the furnace, the nominal capacity is approximately 100 gross tons. The furnace shell is oval and the maximum inside dimensions are 29 ft. long by 20 ft. wide; while the distance from the fore plate line to the bottom of the furnace is approximately 5 feet.

Six 16" graphite electrodes are used in groups of three, with each group being connected to a 10,000 KVA transformer. While the transformers are connected in parallel on the primary side, the secondaries are entirely independent and operate as individual three electrode groups. Triple voltage control at the will of the operator is provided with a range of from 275 to 250 volts no load for the high voltage; 200 to 150 volts no load for the intermediate voltage and 150 to 100 volts no load for the low voltage. The electrical equipment is very flexible, and the two groups of electrodes can be operated either individually or as a unit.

Charging is accomplished by an open hearth charging machine, through two standard open hearth doors at one side of the furnace, while additional operating doors are placed at the opposite side of the furnace in case access to the furnace is needed for patching bottom and working the heat. This furnace is, unquestionably, the largest electric furnace in the world.

HIGH FREQUENCY FURNACE-FOUNDRY

The pioneer foundry installation of Ajax-Northup Coreless Induction furnaces was made in January, 1927, at the Beaver Falls plant of the Babcock & Wilcox Tube Company. The equipment has now been in daily production for over two years, and the results and experience obtained are most interesting.

The metals most usually melted are of the heat, chemical and abrasion resisting type requiring pouring temperatures of from 2900° F. to 3200° F. High Speed steel and other alloys are occasionally made. The average daily production of this foundry is 4000 lbs. per 9-hour day by running two shifts.

The outstanding advantage this installation has shown is its ability to reproduce analyses time after time. For example, in a series of twenty-five consecutive heats of an alloy containing 28% Cn., 8% Ni. and .50% C, the variation in chrome was not over 1½% between the high and the low; the nickel did not vary ¾% from the high to the low; and all carbons were within .06%. This series of heats was made from miscellaneous scrap, not new metal.

The following are some of the different alloys which are run in the furnace:

Cr.	Ni.	C.	
18.80	9.0	.20	Heat and corrosion.
25.0	10.0	1.15	Abrasion resistant and hot work tools.
18.0		.25	Corrosion resistant
16.20	65.70	.50	Heat resisting
22.0	23.0	.40	Heat resisting
28.0	6.0	.40	Heat resisting

High Speed steel and various other alloys.

The log below shows typical results obtained with analysis of scrap charged and analysis of resulting pour.

Heat #——

Analysis metal charge—19.60 Cr. 8.6 Ni.—.2130
Analysis metal poured—18.00 Cr. 8.96 Ni.— .190

Size pour—300 lbs.
Crucible—Acid—156th Heat.

The log below shows the meter readings, etc., during a typical 1000 lb. melt of 22 Cr., 23 Ni. alloy:

Time in Min.	Gen. Volts	Gen. Amps.	Gen. Kw.	
0	900	200	175	—Pouring temperature 2900°F. Min.
5	1000	182	175	—Time to melt—2 hours.
20	1000	175	175	—Kw-h. measured at input to motor—490.
35	970	185	175	—Kw-h. per 2000 lbs.= 980.
50	900	200	175	
65	940	200	175	
80	900	200	175	
95	900	200	175	
110	900	200	175	
120—Poured				

Average kw-h. per ton on the various alloys runs approximately 950 in the 1000 lb. furnaces and 850 in the 400 lb. furnaces.

These figures are measured at input to motor and include power used to hold temperature constant during the pouring period. When high speed steel ingots are poured, some installations have shown as low as 660 kw-h. per 2,000 lbs.

Metals are usually melted in acid linings which give some 200 odd heats before they are replaced. The four-furnace equipment, of which only one furnace operates at a time, gives excellent means for

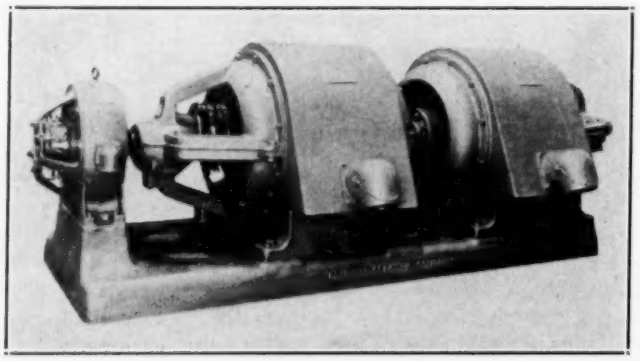

FIG. 13.

keeping the production of the shop up to normal. The spare furnace in each size permits repairs to refractories without interruption of the melting schedule.

A brief description of the melting equipment follows:

The furnaces are typical Ajax-Northrup coreless induction furnaces and are energized by high frequency current. This current is supplied by a motor generator set. See Fig. 13. The motor driving the generator is a synchronous motor rated 250 H.P., 2200 volts, 3 phase, 60 cycles. The generator is single phase and is rated 150 kw.

The motor generator set together with starting switch, condensers, etc., is housed in a room, which is closed off from the foundry proper, but is adjacent and under the same roof. Ventilation is provided to prevent over-heating, and the room is kept free from dirt and fumes.

The generator control panel, which together with condenser controls, regulates the furnace production, is mounted in the wall of the generator room. The face of the panel with meter and switches is toward the furnaces, and the operator has but a few steps to go from his furnace to the controls.

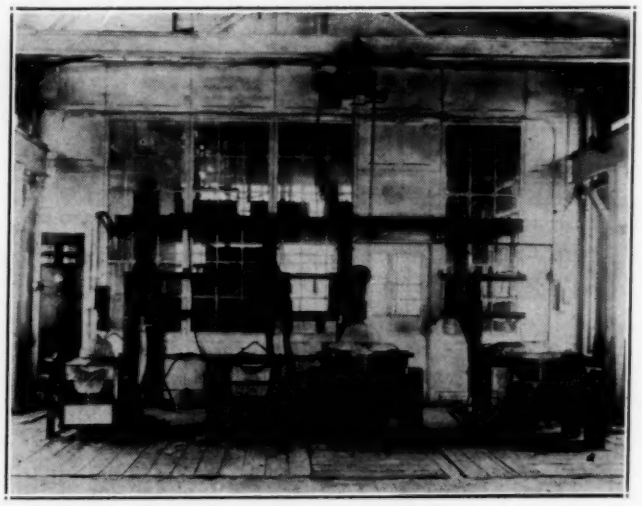

FIG. 14.

Four furnace units, two of them holding 400 lb. charges and two holding 1,000 lb. charges, are mounted in a row about 6 ft. out from the generator room wall. Switches are provided so that any one of the four furnaces can be thrown into service in a few seconds. All four furnaces are of the type which "tilt around the spout" and are tilted by means of an electric hoist, operating on an I beam over the back of the furnaces but well above them to give ample head room. See Fig. 14.

Fig. 15 shows the elementary wiring diagram of the furnace circuits.

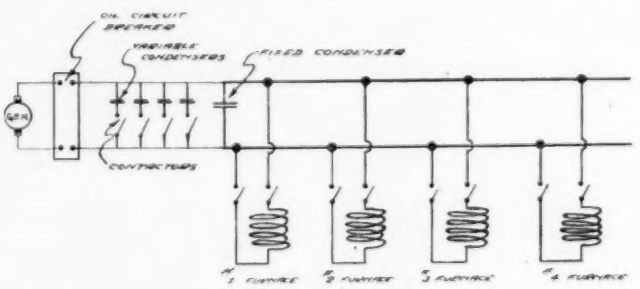

FIG. 15.

Metal is poured from furnace into ladles which have been pre-heated with oil and from the ladles into the molds. When small molds are poured, and the time for pouring off the heat extends over several minutes, a small amount of power is turned on the furnace to maintain a constant temperature.

The equipment is now well past the experimental stage, and the data given above are typical of day in and day out performance. The uniformity of alloys cast and their invariable high quality have resulted in increased demand for the product. A considerably larger installation is now being considered.

*Modern Trends in Stoker Design**

By OTTO DE LORENZI†

While the title of this paper is "Modern Trends in Stoker Design" it might be well to review briefly some of the earliest stoker history.

On June 14, 1785, James Watt, inventor of the steam engine, filed "specifications of patent" with the English patent office wherein he laid the foundation for the modern stoker and furnace.

Watt recognized that coal is made up of a number of constituents and he provided for the burning of coal progressively. The patent states that the operating principle caused "the smoke to pass over and through the more advanced combustion at the bridge end of the grate." Thus his stoker, in a crude way, provided for the combustion of the various constituents at different stages of the combustion process. In establishing this principle of stoker operation, he was as fundamental as in his basic designs in the steam engine field.

Some years after Watt had laid down his principles of stoker operation, a number of patents were granted which immediately forecast the modern chain grate, as well as the modern underfeed, stoker. Since early history is so definite in separating stokers into these two classifications, our discussion will be carried out on similar lines. First, the historical trend of the chain grate stoker and then the historical trend of the underfeed stoker will be reviewed. This will then be followed by a discussion of the modern trend of these two types of machines along with their furnace design.

In 1848 a patent was granted to John Jucke which covered a "Mechanical Fuel Feed Apparatus." This invention introduced the first chain grate stoker and very definitely made use of Watt's principle of progressive combustion.

In 1868, Taylor patented a chain grate similar to that of Jucke. In his design, however, he realized the possible losses at the rear of a chain grate stoker. To overcome this, he provided a water cooled device. This device spanned the rear of stoker in such a position that ashes would be crowded up and over it into an air tight ash pit, separated from the stoker pit by a bridge wall. This device is the forerunner of the modern water back.

In 1870, Burley made use of the dutch oven construction in connection with internally fired boilers and also introduced the power drive.

The foregoing patents contain all the underlying principles incorporated in the modern chain grate stoker of the natural draft type.

It remained for an American, Eckly B. Coxe, to patent and develop the first successful forced draft traveling or chain grate stoker. During 1892 and 1893, Mr. Coxe applied for a large number of patents on this type of stoker. These patents covered such features as the rear arch furnace, air admission over the fire, a wind box between the upper and lower run of chains, with transverse and longitudinal compartment divisions all separately controlled by dampers, water seal under stoker to prevent air infiltration and many other features which are now being used so successfully. Mr. Frank Richards, Mr. Coxe's attorney, also patented a large number of details on forced draft stokers. Mr. Coxe died in 1894 and further work was stopped until 1908, when Mr. Warren Gentry of the Lehigh Valley Coal Company, which company had taken over the Coxe collieries, undertook further development. This development work was placed under the personal supervision of Mr. William Lloyd. Step by step, the original Coxe stoker was improved, until the modern forced draft chain grate become a dependable and important piece of power plant equipment.

Parallel with the development of the chain grate stoker we see a similar development in the underfeed stoker.

The first underfeed stoker was patented in 1816 by Dowson and Hawkins. In this stoker a retort, having a hinged sloping cover on one end, was filled with coal. The retort was then pushed into the furnace through a door, the bottom part of the retort resting on the grate. A hand operated piston then forced the coal into the furnace, under the fuel and onto the grate. While this was a crude hand method of feeding the coal, nevertheless it is the basis of modern underfeed stokers.

In 1838, John Jucke patented an underfeed stoker making use of a hopper for supplying coal to the retort. The coal was forced into the furnace by a hand operated piston. The retort discharged the green incoming fuel up through the center of the grate, forcing the incandescent fuel over onto the grates.

In 1892, Evan William Jones patented an underfeed stoker having a steam driven ram.

In 1901, a patent was granted to W. R. Wood covering a single retort side dump stoker. The coal was supplied to the retort by a steam driven screw feed. Sloping grates were provided at each side of the retort, these grates having a reciprocating motion which caused the fuel to travel to the dead plates at the furnace side walls. To more effectively break up the coke made in the fuel bed, the grate surface had, in addition to the reciprocating motion, a rising and falling motion.

In 1904, a patent was granted to E. E. Taylor, covering a series of longitudinal sloping retorts having dump grates at the bridge wall end of the stoker. This was the first important stride forward in design which was ultimately developed into the present high capacity, high efficiency, multiple retort stoker.

Under ordinary conditions Taylor's stoker operated successfully. However, when it became necessary to increase combustion rates, large amounts of unconsumed coke and green coal found their way to the dump grates and remained unburned. This resulted in high ash pit losses.

This difficulty was finally overcome by the ap-

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†Combustion Engineering Corp., New York, N. Y.

plication of a fuel support, provided with an interior air chamber, mounted next to the discharge end of the retort in a manner to permit oscillation. The supporting surface was in the form of steps having air spaces between them and communicating with the air chamber. A patent covering this construction was issued to R. S. Riley in 1909.

The next important step in the development of the multiple retort stoker design was the clinker grinder. A patent covering this construction was granted to Maxwell Alpern in June, 1916.

The foregoing three patents cover the fundamental principles on which all the modern retort stokers are based.

The modern forced draft chain grate is most versatile as it will easily handle a wider variety of fuels than any other type of stoker. The following fuels are commonly burned on this type of stoker:

Anthracite
Coke Breeze
Semi-Anthracite
Bituminous (free burning)
Sub-Bituminous
Lignite.

The burning of Anthracite and Coke Breeze is practically limited to the forced draft chain grate. It was for the burning of the smaller sizes of Anthracite that this type of stoker was originally developed. Coke Breeze was first burned successfully in 1916. Semi-Anthracite and the Bituminous coals were first burned in 1919—previous to this time the natural draft chain grate handled these fuels almost exclusively.

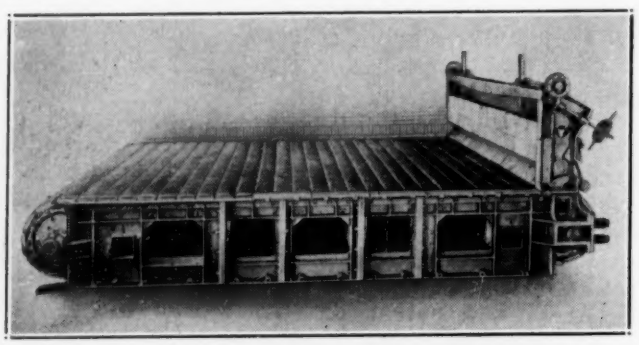

FIG. 1.

As pointed out in the early part of this paper, the Coxe stoker is the pioneer forced draft chain grate. It is, strictly speaking, of the traveling grate type and is used primarily where Anthracite, Coke Breeze and Semi-Anthracite are to be burned.

In this stoker the grate surface consists of small cast iron keys carried on grate bars. These grate bars are attached to forged steel chains which engage sprockets at the front and rear of the stoker. A suitable double worm and wheel reduction, driven by a motor or steam engine, moves the grate surface through the furnace. Between the upper and lower strand of chain are two or three tuyers boxes which are connected to the main air duct. Tuyere slides or dampers provide a means for controlling the quantity and pressure of the air to the compartment or air zones under the grate surface. Thus the active grate surface is divided into a number of transverse areas, each provided with a definite air supply under the control of the operator. A suitable hopper with regulating gate is provided to control fuel bed thickness.

During the latter part of 1916 and the early part of 1917, much was learned of the operation of forced draft chain grate stokers which had not been even remotely expected. In fact, performance guarantees, up to that time, were largely a matter of cultivated judgment. It was found, however, that with a few minor changes, we could operate with No. 3 Buckwheat at 67½ per cent efficiency at 150 per cent rating and 68 per cent at 200 per cent of rating. For some period of time it was thought these results were about the best that might be expected. But later tests and investigations developed the fact that far better efficiencies could be reached. After making a considerable number of tests, the results found were not comparable. There were wide variations in efficiencies even though combustion rates, gas temperatures, CO_2 and ratio of grate to heating surface, were similar. Analyzing a number of tests, led to the conclusion that efficiency was almost wholly dependent on the amount of fines or undersize in the fuel. Ordinarily No. 3 Buckwheat or Barley was presumed to be screened through a 3/16 in. and over a 3/32 in. round hole screen. It usually carried some undersize. It was found that this undersize varied from 12 per cent up to 50 per cent and that our efficiencies went up as the amount of undersize went down. Further study confirmed the fact that there was a direct relation between the percentage of undersize and the efficiency.

Because of the ignition difficulties inherent in Anthracite and Coke Breeze, it is necessary to employ a refractory arch to shield the ignition end of the furnace from the cooling effect of the boiler tubes. The ignition itself is obtained by radiation from the hot refractory surfaces in the furnace. To obtain the proper amount of radiation to assure constant positive ignition, it was necessary to establish the relation between arch height and length.

The single arch type of furnace was accepted as the standard approved design, until a few years ago. The objections to this type of furnace are the tendency for the gases to stratify and the high carbon loss in ash pit and "fly ash". In many cases the stratification of gases resulted in continuous combustion in the boiler passes which caused serious loss in efficiency as well as high stack temperatures, and often caused damage to the superheater. Recent experiments have developed the fact that this continuous combustion may be considerably reduced and often entirely eliminated by the proper use of overfire air. Thus it may be said that overfire air, intelligently applied to the single arch furnace, will give condition of CO_2 which approximate those obtained in the rear arch type of furnace, but without the additional advantage of reduction of carbon in the ash and fly ash.

Recent changes in furnace design have developed the rear arch furnace to the extent that practically all the disadvantages of the older standard front arch furnace have been overcome. Because of the large amount of high temperature refractory surface to which the incoming fuel is exposed, positive ignition is assured at all times. Due to the arrangement of arches and the relatively small "throat" through which the gases must pass, turbulence is

set up and thus assures thorough and uniform mixing of the products of combustion. Because of the fact that the gas and air streams, from the rear end of the stoker, are directed forward by the rear arch, the "fines" in the fuel bed, which were formerly blown in the ash pit, are now re-deposited on the front end of the stoker and consumed. The result is that the carbon loss in the refuse is reduced. Higher operating efficiencies are thus assured with the rear arch furnace, because of the reasons outlined above. Due to the stability of ignition it is not necessary to continually observe the fires, thus allowing the operator to give more time and attention to his other duties.

Until the latter part of 1919, the position of the natural draft chain grate stoker, in the matter of burning mid-western Bituminous coals, had never been seriously questioned. However, in September of that year, the first really successful trials were made with a forced draft chain grate burning Illinois coals. Due to the high volatile content and the long flaming characteristics of these coals, it soon became evident that larger furnace volumes were required than when burning Anthracite or Coke Breeze. However, due to this volatile content it was also possible to increase the height and to reduce the length of the arch.

Various forms of grate surface were experimented with. Due to the low fusion temperatures and slagging action of some of the coals encountered, some types of grate surface heated more than others. The best type of surface proved to be the link with an air space of approximately 8 per cent to 10 per cent.

The grate surface, of the forced draft chain grate stoker, is made up of small interlocking links, forming an endless chain which is supported on suitable skids. This surface is moved through the furnace by a suitable driving mechanism, the rate of which may be varied to meet load and fuel conditions. The drive is usually located at the front of the stoker, thereby putting the top strand of chain in compression and thus maintaining uniform air space between the link ends. A hopper with easily adjusted feed gate is provided. Thus the fuel bed thickness may be varied at will.

A number of compartments are provided between the upper and lower strand of chain. These compartments form their own seals and there is no blowing out of air at the front end of the stoker. The siftings fall directly into the stoker compartment, from which they are removed, by mechanical conveyors, or by steam jets, or they are discharged into the lower run of chain. The recovered siftings are salvaged and added to the station coal.

Stokers of this type are built in varying widths up to 24 ft. and in lengths to 20 or more feet. Thus with large boilers having wide furnaces, it is possible to provide one stoker and eliminate the usual center wall.

Even with ample furnace volume, conditions were produced which introduced new problems. With Bituminous coals, a relatively small amount of excess air is required, and the combustion rates are high. Under these conditions, an excessive amount of smoke is encountered. Careful investigations were made. Analyses of the gases immediately above the fuel bed indicated the cause of this smoke. The furnace gases themselves were stratified and continued in this manner through the boiler passes. The result was reduced combustion efficiency. An examination of the gas analyses disclosed a decided lack of oxygen at the front end of the furnace, where the volatile gases are driven from the coal, and an excess of oxygen at the rear end, where the fixed carbon is burned. These results led to the application of overfire air in the zone where oxygen is deficient.

Forced draft chain grates will burn any of the free burning Bituminous coals or lignites with good economy. High ash coals are preferred to the low ash ones because they more fully protect the grate from radiant heat. The maximum efficiency is developed when burning from 30 to 40 pounds of dry coal per square foot per hour. It is possible to burn from 55 to 60 pounds per square foot, under maximum conditions continuously, at a reduction in efficiency.

The modern multiple retort stoker is designed to burn the various grades of Bituminous and Semi-Bituminous coal. They are handling coals that range from New River and Pocahontas down through the various grades of Pittsburgh coal, Illinois and Indiana coals, the Sub-Bituminous coals and lignites of the West and Southwest. They are at their best when the coals are of a coking or semi-coking nature and have a relatively high fusion temperature of ash. Free burning coals and lignites have a tendency to avalanche, particularly when the dumping type of stoker is used. Low fusion temperature of ash coal causes a certain amount of clinker trouble.

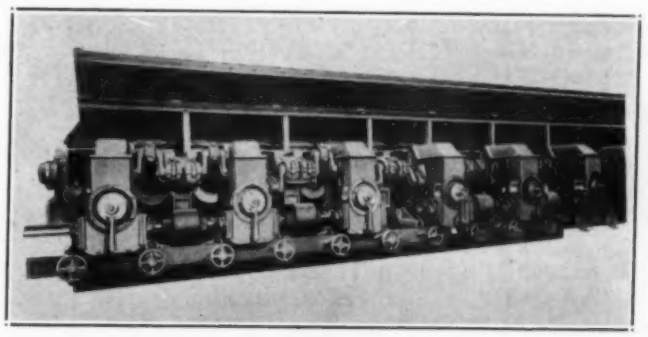

FIG. 2

The recently developed Combustion Engineering multiple retort stoker is an excellent example of modern multiple retort design.

In this type of stoker the coal is fed by gravity from the hopper into the ram box. This ram box is of rectangular shape and is provided with a semi-cylindrical bottom, and so arranged that practically all the wear is taken by liners or wear plates. These liners are adjustable for wear and can be replaced without the necessity of disturbing any other parts.

The displacement of the ram may be as much as 40 pounds as compared with an average of 18 pounds in other types of machines. It is thus possible to maintain relatively low speeds on the main stoker shaft for high capacity. The effect of this change in ram box design is to add additional tuyeres near the front of the stoker, in order to maintain the relationship between stoker length and retort depth.

The capacity of the ram box may be varied to suit the particular stoker length. The ram is driven by a crankshaft, which in turn is driven by a motor, steam engine, or turbine, through either of two sets of spur gears, by means of disc clutches and double work reduction. Thus the ram has two speeds and a neutral selection independent of the prime mover.

The front wall is supported on a rugged cast iron box structure which is also the anchorage for all the stoker mechanism. The ram boxes, driving mechanism and hopper are connected to the front of this casting while the retort sides are connected to the rear. The rear of the stoker proper floats or rides free to allow for expansion.

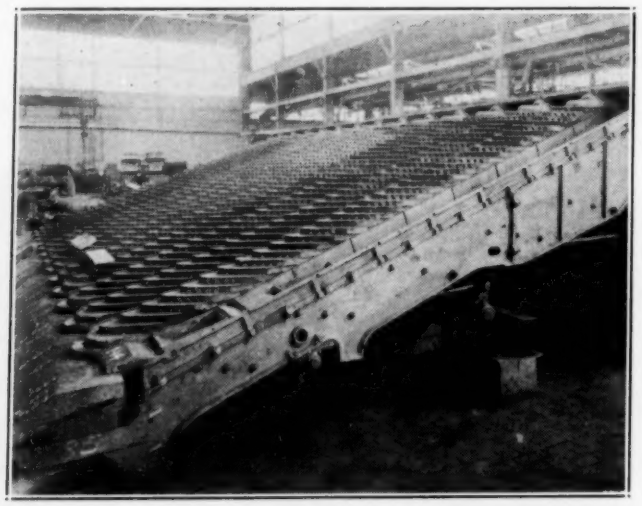

FIG. 3.

The retort sides are rigidly built up in sections. Provision is made for expansion to eliminate possibility of breakage. The upper section of the retort sides are renewable.

The secondary rams receive their motion from the main connecting rod wrist pin, through a heavy lever fulcrumed to a main moving rod. On this rod is mounted a micrometer screw for adjusting the length of the stroke. The adjustment is made by conveniently located hand wheels at the front of the stoker. There is a multiplicity of auxiliary rams, each moving on fixed spacer plates. These fixed plates tie the retort base castings rigidly together. This form of construction eliminates any difficulty from expansion and binding of rams. It also allows the clearance to be reduced to a minimum thus eliminating siftings.

The direction of travel of the rams differs from that in the other types of multiple retort stokers. They do not move downward or horizontal, but slightly forward and upward. This upward inclined motion, which is decreasing towards the rear of the stoker, conveys the fuel to the rear of the furnace, and in addition creates a lateral agitation which breaks up the dense coke formation, in the retort, into a porous mass.

At the end of the underfeed retort there is a reciprocating and air admitting section of overfeed grate. This overfeed section is needed for shaking down the coke left in the fuel. Alternate sections moving in opposite directions give the maximum surface agitation.

The tuyeres are designed with particular attention paid to absorption and radiation effect. Stream flow of the air is provided for and the openings themselves are proportioned for preheated air. The shape of the tuyere is such that there is plenty of surface for heat absorption, and plenty of space for air admission for cooling purposes.

Side wall tuyeres have been developed to prevent slagging or clinker formation on the side walls.

Dump grates are provided on the smaller size stokers. However, with the larger stokers, it is better practice to provide clinker grinders of one, two, or three rolls depending on the conditions under which the stoker is to operate.

With either the dump grate or clinker grinder type it is well to provide water cooled protection for the bridge wall. This prevents slagging of the bridge wall and pit and reduces maintenance.

With the dump grate type the power for operation is derived from a steam cylinder located at some convenient point close to the dumps. A separate motor driven gear is provided with the clinker grinder type.

The air to the stoker is zoned. The location and number of zones depend on the size of the machine and also the plant operating conditions. The damper controls for the various zones are grouped at some advantageous point at the front of the stoker.

Incorporated in the design, aside from fuel burning ability, is the provision made for replacement of parts. The machine is built on a base structure which, under the most severe conditions, should never need replacing. Upon this structure is mounted the grate surface, ram boxes and throat liners. With this type of construction the parts subjected to wear or possible deterioration, due to furnace or fuel bed conditions, may easily be renewed with small light weight sections. Adjustment and damper controls have been reduced in number, simplified, and grouped in accessible places.

From the foregoing discussion of furnace and stoker development one can see that there are definite trends in design. These trends are significant and should be carefully weighed when the purchase of such equipment is being considered. The plant location and the available fuel will determine, in practically every case, whether the multiple retort type or the forced draft chain or traveling grate type of stoker is most suitable. Assuming that the type of stoker has been definitely settled, it remains only to make a study and comparison of the various designs, and to determine the most suitable furnace.

When the fuel is Anthracite, Semi-Anthracite, or Coke Breeze, the forced draft traveling grate is the logical and only practical solution. With this type of stoker the trend is definitely toward some form of rear arch furnace. The actual design of furnace will depend, to a great extent, on the setting height and type of boiler. However, it is best to provide a full rear arch, if it is at all possible.

With large boilers having wide furnaces, it has been customary to provide two stokers with a center wall between them. However, in the very near future, suitable designs will have been established for building stokers, of this type, as wide as twenty-four feet. This will then eliminate the center wall.

Some very recently designed furnaces have been provided with water cooled surface in the side walls,

at points where erosion occurs. This practice will become more general. However, care must be exercised so as not to over-cool the furnace, as the result will be failure of ignition.

In many cases when the fuel is coke breeze there is also available blast furnace gas. In many instances it has been the practice to provide boilers for burning the breeze and others for burning the gas. Furnace designs have now been developed for burning either fuel separately, or both fuels simultaneously under the same boiler. The result is an appreciable saving in equipment costs as well as a reduction in boiler room size.

The forced draft chain grate is most frequently used where the fuel is free burning Bituminous, Sub-Bituminous coal or lignite. The principle reason is that these fuels usally have a low fusion temperature of ash and form large clinkers when the coal and ash are mixed and agitated. Lignite, of course, disintegrates when exposed to furnace temperature and will drift on the grate surface unless the air is zoned and closely controlled. With an inclined grate, when the dumps are lowered, the entire fuel bed may avalanche into the ash pit. However, some of the fuels in this classification may also be handled on multiple retort stokers.

The trend in furnace design with these fuels, on the forced draft chain grate stoker is definitely towards the rear arch construction, and away from the older water back construction. In these cases the arch is considerably higher above the grate than with Anthracite. The throat of the furnace is also increased in width.

To eliminate side wall clinker formation, side wall water boxes should be placed on the stoker side frames. Fuels having a low fusion temperature of ash are extremely hard on the furnace refractories and therefore the maximum amount of side wall cooling should be provided. Water cooled refractory arches have also proven very satisfactory and should be given consideration in every case.

FIG. 4.

Stokers of this type are built up to twenty-four feet in width and twenty-two feet in length. This makes it possible to operate large boilers at high overloads when using a single furnace.

The application of over-fire air, in the zone where oxygen is deficient, is an important advance made to secure more uniform furnace conditions.

The method which holds out the most promise for supplying the air over the fire is one in which a small booster fan is used. In this system the air is drawn from the forced blast duct, by the booster fan. It is then forced toward the center of the grate, through a series of venturi nozzles in the fucnace front. When applying the air in this manner, control of the amount used is secured as well as the necessary turbulence for good mixing of the gas to give uniformly high CO_2. The length of flame, and the amount of soot and "birdnesting" in the tubes of the first pass are reduced. Thus the net results of overfire air are improved operation and efficiency.

Semi-Bituminous and coking Bituminous coals are underfeed stoker fuels. Excellent results are obtained when these coals are burned on the modern multiple retort stoker.

In the design of the modern multiple retort stoker the trend is definitely towards, multiple agitating rams, reciprocating over-feed sections and clinker grinders. Proportioning of retort depth to stoker length is also important because it reduces the ram speed and lowers retort maintenance. All parts subjected to wear should be provided with renewable liners and small replaceable sections. Stoker lengths have been increased so that it is possible to obtain relatively high rates of evaporation with limited furnace width. Air cooled side wall tuyeres are provided in many cases but side wall water cooling is becoming increasingly popular and is replacing the side wall tuyere.

The modern steam generating units having capacities of 300,000 pounds per hour and over, call

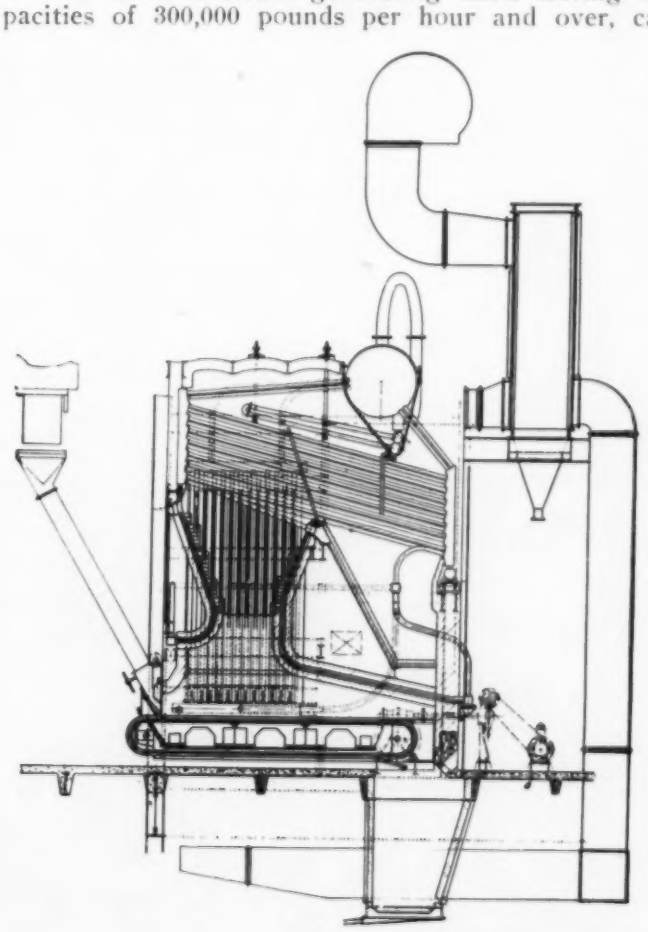

FIG. 5.

for extremely large stoker units . Thus the modern super stoker is being built in widths of twenty or more retorts. The depth of furnace from front wall to center line of grinder pit may be as great as eighteen feet. The clinker grinder pits are made extremely deep and usually have a water cooled bridge wall. This reduces clinker formation and at the same time cools the lower end of the grate. Two or three rolls are provided so that the ash discharge may be controlled to correspond to the varying rate in coal feed.

With these modern types of multiple retort stokers, it is possible to maintain a relatively high furnace CO_2 and at the same time reduce the carbon in ash to an absolute minimum. As a result of the foregoing, it has been possible to maintain efficiencies in daily operation that exceed those obtained on tests a few years ago.

Due to the increasing use, in turbine practice, of stage bleeding for feed water heating, economizer surfaces are being reduced to a minimum, and in many cases are eliminated entirely. In order to maintain the efficiency of the boiler unit it therefore becomes necessary to substitute air heater for economizers. However, the amount of preheat and the preheater surface is limited by the temperature of air which it is safe to use, without running into excessively high stoker maintenance costs. The general trend, now, is to limit the air temperature to approximately 350 deg. Fahr. even though this temperature has been exceeded in a number of cases. The actual practical temperature is, in many cases, determined by the nature of the coal instead of the stoker itself. With Iowa coals the temperature will be lower than with West Virginia coal if slagging in the fuel bed is to be avoided.

In conclusion it may be said that modern stoker fired units are far more efficient than those of ten years ago. New developments in stoker and furnace designs are being brought forth each year so that in the very near future it will be possible to practically equal theoretical efficiency in daily operation.

Electric Heating and Welding Conference

AUSPICES

PENNSYLVANIA STATE COLLEGE

AND

ASSOCIATION IRON AND STEEL ELECTRICAL ENGINEERS

NOVEMBER 13TH AND 14TH, 1929

BLUE ROOM, WILLIAM PENN HOTEL—PITTSBURGH, PA.

CO-OPERATORS

THE INDUSTRIAL PLANTS, WESTERN PENNSYLVANIA
THE CENTRAL STATIONS, WESTERN PENNSYLVANIA
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THE WELDING EQUIPMENT MANUFACTURERS OF AMERICA
THE ELECTRICAL HEATING UNIT MANUFACTURERS OF AMERICA
THE IRON AND STEEL INDUSTRY

PROGRAM

Wednesday, November 13th, 9:30 A. M.

"Pipe Welding"

"Lead and Salt Baths for Hardening and Tempering"

Luncheon 12:30 P. M.

2:30 P. M.

"Electric Welding of Heavy Materials"

"The Electric Annealing Furnace"

Thursday, November 14th, 9:30 A. M.

"Steel Melting Furnaces"

"The Induction Furnace"

Luncheon 12:30 P. M.

2:30 P. M.

"Electric Galvanizing"

"Use of Electricity in the Development of Tool Steels"

Report of the A. I. & S. E. E. Special Committee on Bearings and Special Study Regarding Lubrication of Anti-Friction Bearings on Mill and Crane Motors—

F. D. EGAN*
Chairman Special Committee on Bearings.

Discussion

A. J. Standing†: Mr. Chairman and Members of the Association: I don't think a report like this ought to become part of our record without due comment.

I want to compliment Mr. Egan on the work he has accomplished through his committee.

I rather feel that the answers are chaotic, to say the least. In other words, they indicate a large percentage of guesses, and some of those guesses are miles away from the mark apparently.

These answers have been given in good faith, but I am pretty sure we agree that a good many of them do not represent actual operating conditions.

I made a reply to that questionnaire, and I want to outline the method we employed in making that reply. I called a little meeting, including the lubricating man of the plant—my assistant, my general repair foreman, and four outside division foremen. I had them in my office and I read each question to which I had already made tentative answers. I got their views and tried to correlate their opinions. Sometimes they didn't agree with my tentative answer at all, and then we started an argument. The final answers we turned in, which, while they may or may not have been in line with the consensus of opinion, were at least the opinion of the men who are directly connected with such roller bearing applications as we know of in our plant.

Two or three things resulted from that method of going at the proposition, and they impressed me as follows: First I think a peak of the wave of an anti-friction bearing application as a cure-all for everything is past. I think anti-friction bearings are now on the basis where they are going to demand more sane investigation and more sane application, if we are to derive the monetary results which we look for.

That has been evidenced by some of our applications, which by the way, have in each case been in the hardest service points. It is only fair to make that statement, for the reason that the bearings which have been applied in a few cases in standard location, where almost any bearing would have gotten by, have operated in one hundred per cent shape, which we expected. But those bearings which were applied in the most critical conditions have required varying attention and have given varying results.

In answer to some of these questionnaires, in regard to letting the bearing go for a year or two years, I might say that some of ours have failed in two weeks, depending on the nature of the service. I have in mind particular applications, where there are mill table drives, adjacent to a continuous shaped mill, where, on the heavier sections, when the bar comes through the mill, the tables are actually driven at two and two and one-half times normal speed for a period, with each bar coming through the mill.

The bearing situation on those particular motors varies with each bar that is rolled. And how are you going to get conditions that are uniform if you take grease based on a low-speed motor and then run the motor two and one-half times that speed.

We have had some grief on those motors. The result is we have experiemented with our greases and have changed our original grade of grease and considerably changed the period of attention.

While these remarks may not be informative, I hope they are bringing up the questions that I think are in the minds of a great many of us and are indicated by these answers. There is a lot to be learned, and I think the work of this committee must continue until we get to some more reliable basis of fact than we have at the present time.

I question whether we are justified, as Mr. Cramer pointed out two or three years ago, in going to a wholesale application of anti-friction bearings. We find that sleeve bearings in a great many cases require practically no attention. In such cases it is economical to let them alone, and only where sleeve bearings are a continuous source of expense are we justified in expenditures for improvement. If roller bearings are to be the answer, then we must make the best roller bearing application we can, and at the same time educate our men in the plant from the foremen and the lubricating men, to the proper care and attention of roller bearings. The tendency of these men was to feel when we had cured our screw down with roller bearings we were through with that job. But we realize we are not through with it.

I hope that as a result of these more or less indefinite comments, someone else will come along

*Electrical Superintendent, Bethlehem Steel Co., Lackawanna, N. Y.
†Elec. Supt., Bethlehem Steel Co., Bethlehem, Pa.

with something from which we can benefit, because we find there is a long story to be learned before anti-friction bearings are 100 per cent satisfactory in our work.

J. L. Brown*: This is a very interesting subject I am sure, and has become more so during the past few years.

Being associated with Mr. Egan's committee, I was impressed today, as before, by the great variety of answers on this subject of greasing bearings. Of course, that was only one of the parts of the work of the committee, but as that seems to be the subject about which there is the least definite assurance, I suppose that is the one we want to discuss.

In our experience in applying roller bearings and ball bearings to motors, we have found that there is a great tendency on the part of a good many users to pay no attention to the kind of grease that is used, and even though a certain grade which has proved more or less satisfactory has been recommended, the recommendations are often ignored. So I think one of the main things that we want to get before us is the fact that the grease question is an important question, if we are going to get the best service out of ball or roller bearings.

There are a great many greases which are useful for other purposes which are no good at all for ball or roller bearings, and I would like to refer back to one of the answers that was given, which Mr. Egan read—and there is no such thing as a ball or roller bearing grease.

In a certain sense that may be true, but still there are certain greases which are much better adapted to use with ball and roller bearings than a great many others. In general, I suppose we might give a specification for grease which is perhaps rather broad, but it rules out quite a number of unsatisfactory greases.

In my opinion, a suitable grease for roller bearings should be compounded from a pure mineral oil, using a calcium or sodium base soap. My preference is for a sodium base soap, because these greases are less liable to come apart, that is, to separate into oil and soap. Such greases have a rather stringy consistency and stick to the surfaces which need to be lubricated.

There are greases which can be bought on the market, which have animal fats in them or vegetable oils, and they, I should say, should not be used for ball or roller bearings because even though they may not have acids present at the beginning, during operation they will liberate acids which will attack the surfaces of the balls and raceways and the excellence of the bearings will be destroyed because the surfaces will no longer be polished as they were at the beginning.

Having decided on a grease from a pure mineral oil and a calcium or sodium base soap, we could state further there should be no fillers of any kind in the grease. Some have used fillers such as mica or graphite. But for ball or roller bearings I believe these should not be used, because the fillers will occupy space, and since the bearings run with very small clearance these fillers will tend to overload the bearings by pinching the rollers between the raceways.

I think that the other most important consideration is perhaps the consistency of the grease. There are greases which will maintain a rather uniform consistency over a very large temperature range, and these large ranges of temperature are found in steel mill work, as much or perhaps more than in any other, so that this sort of grease ought to be secured. There are very few greases which will do that, and they have been developed only within the last few years.

There are some greases which have a drop point of something like 150 degrees Centigrade and for the higher temperatures, I suppose this ought to be very satisfactory. Indeed I know of a number of steel mills that have used this sort of grease very satisfactory.

For roller bearings particularly, a rather lighter grease than that one to which I referred is probably necessary, except in hot locations, because the rollers, unlike balls, tend to squeeze the grease out of the bearing and gravity has to be relied on to bring it back onto the surfaces that are to be lubricated.

On the other hand, we should not have a grease which will melt at the operating temperature and become oil for two reasons: First, because we get right back to the condition that we have with oil lubricated bearings, the difficulty of keeping oil where it belongs. Another reason is that a soft grease, which goes into the form of oil, will begin to churn at the high speeds and will overheat the bearings and probably destroy itself due to the churning.

The grease should at all times remain in a semi-liquid form. Cup greases usually become hard at lower temperatures and then become very thin at the higher temperatures. So it is desirable to avoid those and to choose a grease which remains in a fairly fluid state throughout the whole range of operating temperature, but which at the same time will not flow too freely, flowing only slowly into the places where it is desired to have it lubricate the bearings.

Another point is the frequency of lubrication. If the proper grease is chosen it will not be necessary to lubricate the bearings frequently. I think some of the diversity of answers in regard to the frequency of lubrication is due to the use of different kinds of greases. The grease which becomes fluid very rapidly will flow out of the bearings and then more needs to be put in.

The proper kind of grease will stay in the bearing for a long time.

In some shovel motors (the same type as used in the mills), at the Utah Copper Mines, they applied this grease at the beginning of the operation, and after running, I believe, six months, they tried to put in more, but found there was no room. On taking the bearing housings apart, they found the grease was in perfectly good condition.

It would seem that with the proper kind of

*Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

grease, if this can be established, it would be unnecessary to lubricate at very frequent intervals, even though the temperature is quite high. But until such a grease is discovered by the user as that which suits his conditions best, certainly the bearings ought to be examined frequently and the grease supply replenished so the bearing will not run dry, because although anti-friction bearings, so-called, do not depend on a film of oil or grease to carry the load, still they must be lubricated in order to get satisfactory operation.

Now as to looking at the bearings and examining them to see what condition they are in, if the right kind of grease is in the bearings, it will be unnecessary to do this very frequently, but because there are so many greases which are really unsuitable, it therefore is still necessary, I think, to look at them fairly frequently to make sure that they are in good condition.

If one has by some mischance begun to use a cup grease or a grease which acts in the same way, he will find that after a period of time the grease is separated into soap and oil and the oil will have disappeared and the soap will remain close up to the surface which should be lubricated, and the soap, of course, won't lubricate.

If fresh grease is put in on top of that, the soap will be pushed up against the surface that should be lubricated, and the bearing will not get the benefit of the new grease which has been put in. That is a condition that arises when improper grease has been used.

With these points, I think I shall close my part of the discussion, these being the points that appeal to me at the present time as being, perhaps, some of the most important.

C. C. Pecue*: You have taken me unawares: the Electrical Engineer of the Bethlehem Steel Company Plant at Lackawanna has very aptly stated that Mr. Herd, his assistant, has probably taken more time recently on this subject that the majority of men have, due to the fact that we are adopting many motors with the anti-friction bearing.

Mr. Brown has stated practically all that can be said as far as my experience tends. I have tried out in many instances the larger bearings. I will enlarge a bit on this last statement. In our plant we have had a little experience, as it were, on the electrical, or in other words, motor-bearing lubrication, with the anti-friction bearings. But we have had a large quantity of varied bearings of types high speed, large and small.

Mr. Brown, as I said, told the whole story, but I want to ask one question before I go further. If we are going to use a liquid grease, why couldn't the designer design a motor bearing so that we could tell something about the level of the grease in the bearings?

It has been said that we do not want any fillers in the grease. Absolutely, we do not. But there are certain kinds of graphite grease that are manufactured today. By the way, I am not advocating any particular grease, that has done has done remarkable work in our plant in the heavy Timken roller bearing work. We have run two and a half years on these greases with the most ideal success.

We have not come to the point of an expensive grease. We are very careful of the amount of grease used and where it is applied. We are using a cheaper grease in some instances and a higher grade grease in others.

Mr. Egan knows as well as I do that we are very careful at our plant to be sure that we have the proper grease applied where it ought to be. That means continued energetic examination and inspection of the lubrication of our entire plant. I might say that I myself am only there as a leader. Everybody is on his toes in our plant as far as lubrication goes.

Let me tell you some instances. I said at first that our motor bearing proposition was small in comparison to all anti-friction bearings. We have many mould cars running today, five and one-half years old, without a single failure, where the ingot is stripped from the mould with such force castings which support the moulds are broken, but we have never had a failure on those bearings.

Recently, we had a loose wheel on one of our journals on one of these cars; we took the wheel off and removed the bearing from the axle, and found it in ideal condition. A cheap lime base grease was used here. In other instances as on cold saw work we have run two and one-half years and taken them apart and found they were in good condition. We do not find any soap sediment in our bearings, due to the fact that we do not allow that kind of grease to go in. I can't enlarge on this, but I do tell you, first of all, that the roller bearing proposition must be accurately cared for.

Mr. Brown spoke of the soda base grease. Let me tell you something. The soda base grease, similar to what you are using on your automobile gearing today, providing it is a high-grade grease of the proper consistency, is the most ideal condition a man can put into a roller bearing, due to the fact that there is always a film. The soda soap does not drop the soap base as lime and calcium soap does. Consequently it is always there in a fluid form. These greases are made with a cylinder stock, and that cylinder stock is what you wish to have. We have a grease in our plant that is a tallow base grease, and we are using it extensively. We have had the manufacturer color it red so as to distinguish it from a cheaper grease which we use. This coloring will greatly assist the operator. I don't think I can enlarge very much on what I have said but there is one thing I want to speak about, that is, you cannot rely on a stated time of application in all instances. In rolling mills the radiated heat is a great factor. If you have the bearing where it is cool and running intermittently the bearing does not need to be filled as often as when running steadily, or where the bearing is near hot metal.

We had an instance with a Westinghouse motor a few years ago, where we showed a radiating heat of 60-some degrees. Consequently you had to adapt your lubrication to the temperature in which your are running your motors. We are very particular about the lubricants we use. It was also said here that the purchasing agent has a lot to do with it. But the purchasing agent in our place is working hand and hand with our department in everything

*Lubricating Engineer, Bethlehem Steel Co., Lackawanna, N. Y.

we do. So he is eliminated as far as dictating what we should do about lubrication.

The roller bearing has come fast, and if it is properly cared for it is going to help you in many instances. I want to tell you that on table roller bearings in our mills we are using a cheap grease because we know we have to overfill them due to the fact that the heat is carried out to the necks and into the bearings. We overfill them for this one purpose: to squash the grease out of the end to carry away the dirt. Knowing that after it runs a short time that the grease will sink back into the cellar and form the proper level. If I could answer any questions, I might get a line on what you would like to have me talk to you about. Otherwise from that, I do not have anything more to say. But our experience in years gone by has taught us this one thing: you must be sure that your grease is right. You must know the condition of the bearing, the temperature the bearing is running in, the speeds, and you must have a good grease. What I mean is this: A grease without heavy fillers, a grease that will be as Mr. Brown said, of a soda base composition for high speeds—lime bases will work in many slow places and a grease that will spread and not slop out.

If at any time I can give you my experience I will glady do so.

Harry A. Winne*: I haven't any information to give this meeting. I came here looking for information. I did have a little something to do with starting this questionaire.

It came about in this way: We had received several requests from people who have bought the MD-400 motors, asking us how frequently the roller bearings should be greased. Our designing engineer came to us, who are responsible for the application of this motor, and asked us what they should say in the instructions as to how often these bearings should be greased. We had to admit that we knew about as little or maybe less than they did about it. So we started to try to find out, and I wrote to Mr. Egan. I knew he was chairman of the special Bearing Committee of the Association. I felt possibly they might have developed some information along this line. I also wrote to several members of the Association, who I knew were using a large number of auxiliary motors.

I got replies that ranged all over the lot. For motors in heavy service, such as screwdowns and live tables in the blooming mills, the recommendations ranged from greasing once a week to about once in six weeks. For motors in crane service or comparatively light duty, the recommendations ranged from greasing once a week to once in six months. In fact, I think one man was even willing to let them go a year.

From the replies which I received we tried to strike an average, and we are recommending, when we are asked for a recommendation, that the bearings on motors in heavy duty service be lubricated once in two weeks, and those on crane service and similar service, be lubricated once in two months, which seemed to be fully as often as the majority of replies justified.

*General Electric Co., Schenectady, N. Y.

Whether those recommendations are the best, we are not prepared to say. They simply represent what we thought to be a safe average of replies we received. We didn't receive very many replies, and we certainly would like to hear from a lot of others. But instead of sending information to us, it would, of course, be better to have it go to Mr. Egan of the Association's own Bearing Committee, which can then correlate it and make recommendations which can be followed or not as we choose, of course, but which will give us at least a guide.

Judging from the wide diversity of replies, I think it is a subject that can be given some little discussion with good results to all of us.

A. M. MacCutcheon*: I think that all I can add to what has already been said, today and on other days, is that our experience with anti-friction bearings has lead us, on our alternating current line, to make only anti-friction bearings. We were entirely prepared to make both anti-friction and oil bearings and were supplying them regularly. But because of the falling off in demand for the oil bearings on A.C. motors, we have dropped the manufacture of such motors.

In the various discussions on anti-friction motors very little has been said on the question of fits. I have in mind a few facts that we think we have established, and will mention them to you.

On a shaft of about two inches in diameter, there must be a half a thousandths tolerance on the shaft for manufacturing reasons, and as I recall it, approximately .008 variation is permitted on the inner race of the bearing. We have found that the best fit is from about .0002 loose up to .001 tight.

I think on such a size bearing as that, no one desires that the bearing should be even .0002 loose on the shaft. Nor do I think they desire it should be .0011 tight. But we find in grinding shafts that the men in the factory tend toward the upper limit which is permitted. We also find in measuring bearings that are received, they tend toward the lower limit. I would like to pause for a moment to compliment the ball bearing manufacturers on the accuracy of the product as it is shipped, with regard to this particular dimension I am discussing. I think we have never found a ball bearing in the plant that was outside of the variation that is permitted and which is published by them.

But with the shaft tending toward the upper limit and the bearing tending toward the lower limit, it is probable that we will not get the .0002 loose. I think on a two-inch shaft that about .0008 tight is the most desirable condition.

It has been said in our own plant that it is not possible to drive a bearing on, which is .0008 tight, without using a very heavy hammer, but we have demonstrated that it is possible, with an ordinary hammer, to drive a bearing on which has such a degree of tightness. There is no particular difficulty in getting the bearing off if it is desired to remove it. I think all ball bearing people agree that the bearing must be tight on the shaft to avoid peening the shaft. The nut alone cannot be en-

*Engineering V. P., Reliance Electric & Engineering Co., Cleveland, Ohio.

tirely depended upon unless the bearing also is tight.

In gathering further information regarding the ball bearing application, under the A. I. & S. E. E. committee, it would be very interesting if, information were sought on this question of fits. It is very vital to the user since if a bearing is put on so tight that great difficulty is experienced in removing it, it is not good; and if it is put on too loose, that certainly is not good.

We used to put the bearings on by the use of hot oil, and the reason we gave it up was that we found we didn't have the same knowledge of how tight the bearing was after it had been put on. You certainly can use hot oil and get a bearing on that is .0015, .0025 or even .003 tight. I think if you do that you are getting toward expanding the inner race and binding the balls.

S. N. Roberts*: I am like Mr. Winne—I came to get information. All of the men who have talked from these large plants have about a thousand motors, where we have one.

It has been a problem with us for several years as to whether to adopt anti-friction bearings or keep on with the bearings that we know all about and have been pretty successful with.

However, recently we decided that most of the motors that we get in the future will be of the anti-friction type. In the few that we have, the same problem that we have been talking about, the lubrication, has bothered us a good deal, because there are some small and some large motors with different style bearings.

The main experience we had before was on our mechanical applications, that is, on machinery. We had some on very hot shafts. These were waste-heat fans, and the shaft's heat would expand the bearing so that we couldn't use them. The shaft itself would be real hot and not the bearings. We went back to using the other bearings on that particular application.

What we would like to know now is just exactly what everybody here has asked—How do you know whether you have enough grease on the bearings, as we are using at present what the manufacturers have recommended? But that is the same problem that you have on any grease bearing.

You can take a man with a gun, and if he is not closely supervised by someone, he will use 100 per cent more grease than another man will on any type of bearing. We have recently had some trouble in leaking oil on the cranes with roller bearings. These crane bearings have to be clean, because if there is any grease which drops on the product we get complaints. From my standpoint, it is a lot of grief to me outside of the operating problem. I don't mind the bearings being well lubricated, but the other fellow doesn't want grease on the product. We are still working on that now, trying to change the packing in the bearing to see if we can't keep from dropping grease on the product.

What I expect to do now is to get a lot of information from everyone in this meeting, and by this time next year possibly we will all know enough to help each other out more than I have been able to help you. I am sorry I can't tell you anything more. I am simply glad to be here.

William B. Connally*: I am like some of the others—I came here rather to learn about anti-friction bearings. I didn't expect to say anything. In our small plant down in Alabama City, the Gulf States Steel, we are getting into the use of anti-friction bearings in a small way. Last year we made some applications in a new power plant, and we have some rather difficult applications above the boilers, where the temperature runs very high.

Our operating men tell me that the greatest difficulty is in keeping the grease in the bearings. Of course, I suppose the answer to that is: If you get the right lubricant, you will not have much trouble. We have been trying to find the right lubricant for these particular bearings, which happen to be Timkens. We have had one or two failures of these bearings, probably not because they are Timkens but because we do not have the right lubricant. However, these failures that we had were not in hot places that I have just mentioned. They were down on the basement floor, where it was not hot but the motor speed was rather high, about 1800 R.P.M. This is a 150 horse power motor.

In the next few months we expect to add a lot of auxiliary motors, Mill type motors, in our blooming mill, and it looks as though they will be provided with anti-friction bearings. We are very much interested, of course. Anything we can find out in advance in regard to the application of these bearings and the lubrication of them will benefit us. We expect to get some new cranes in connection with this new blooming mill and also with the plate mill which we are about to install. Of course, we will have anti-friction bearings on the cranes. I believe the specification reads that way.

I can't add anything to the discussion. I would be glad to hear from anyone who can give me any information on this subject.

*Elec. Supt., Atlantic Steel Co., Atlanta, Ga.

*Elec. Supt., Gulf States Steel Co., Alabama City, Ala.

*Notes on the Damping-Down and Restarting of Blast Furnaces**[1]

By C. S. GILL (Consett)

INTRODUCTION

The frequency with which during recent years[2] it has been necessary to shut down the furnaces, and await the settlement of the numerous trade disputes, has brought the whole question of the damping-down and restarting of blast-furnaces very much to the front, and it is in the hope of encouraging a frank interchange of ideas on this important subject that this paper has been written.

To many furnacemen, the period immediately following the renewal of operations, after a prolonged stand, is a time of stress and trial, in which hard and high tap-holes, together with other troubles—such as iron over the slag fall, and slag back in the tuyeres—play prominent parts, and if means can be found to eliminate these unpleasant features it will be to the advantage of all.

Each blast-furnace manager has his own system which he follows when it becomes necessary to interrupt temporarily the working of his furnaces, one which has been developed to suit the local conditions of the particular plant; but besides this on every such occasion the exact method to be adopted is dependent upon many factors, of which the three mentioned below are some of the most important:

(a) Probable Duration of the Stand.—If the stand is to be of short duration there is no great difficulty in estimating the suitable coke blank, and, by the exercise of ordinary care, in seeing that this is quite definitely in the hearth before the blast comes off; and it is then possible to obtain perfectly satisfactory results on restarting. In the present paper, however, the author has in view more particularly that damping-down which is necessary when the expectation is that the furnace will stand for an indefinite or prolonged period.

(b) Condition of the Linings.—Where the linings are known to be seriously damaged or worn it becomes a matter of discretion as to whether they are in such a condition as to warrant the blowing-out of the furnace, raking out the material, and doing any repairs to the brickwork which might be necessary; in that case the furnace would be blown-in again in the same way as starting a new furnace. This is outside the scope of the present notes, but it is certain that, given reasonable care, it is possible to damp down and restart practically any blast-furnace in such a way as to do a minimum of damage to the furnace, and to have it on to full output within a week of commencing the task of blowing-in, whilst at the same time escaping most of the trials usually associated with the process.

(c) Whether All or only a Proportion of the Furnaces are to be Damped.—If only a proportion of the furnaces is to be damped down it is possible to obtain exceptionally satisfactory results by adding a comparatively small blank of coke—with the usual precautions—and by keeping the downcomer valves open, to obtain a pressure of gas from the other furnaces during the stand. This quickly eliminates all combustion, and allows the furnaces to cool down in a condition which permits of the blowing-in being accomplished with practically no difficulty at all. Details are given later of a case in which this was done, and the furnace stood damped for eleven months.

The following are the general principles and methods adopted at the works with which the author is connected whenever a prolonged shut-down is necessary. No particular novelty is claimed, except that they have eliminated trouble from this usually troublesome undertaking.

DAMPING-DOWN

Realising the futility of expecting an easy blow-in unless the damping-down be most carefully performed, very particular attention and study was devoted to this most vital part of the whole operation, with the result that it was felt that the condition to aim at in a perfectly damped furnace is one in which all reaction within the furnace is completely stopped. If it were possible to immediately quench the furnace after the last tap before the stand, blowing-in would be a simple matter, but as this is not practicable every endeavor must be made to approach as near as possible to this ideal. This means that all air must be excluded from the furnace during the period of the stand, and, even assuming the shutting-down has been satisfactorily performed, the ability or otherwise to accomplish this will be an important factor in the results obtained. This exclusion of air is essential if there be any ore in the charge, and should doubts be felt as to the possibility of effectively accomplishing this it is wise to omit ore altogether. Air leaking into a furnace damped with an all-coke charge is wasteful of coke, but does not prevent a quick and easy blow-in. It is always wise to have an excess of coke rather than a deficiency, and, as just explained, this is the more necessary if the furnace be old or if the stand be for a prolonged period. But in any case sufficient coke should be charged to allow for a small proportion being burned before the blast is turned off, as this is a comparatively cheap price to pay to ensure that no fluid iron or slag is left in the hearth of the furnace to solidify and cause trouble when blowing-in. In those cases where ore is charged, the coke blank must be of such a size that it will prevent any reduced ore from reaching the fusion zone, or it will quickly percolate down into the hearth.

As is well known, the gas from a furnace which

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*Presented before the British Iron & Steel Institute, September, 1929.

[1] Received May 30, 1929.

[2] Written in 1926.

is being damped is very fiery and explosive, and it is usually risky to reach a condition where there may be a danger of the gas pressure falling owing to some furnaces being off whilst others are not yet ready to come off, so before commencing the damping a note was made from previous experience, or by calculation, of the exact number of rounds which should be necessary to complete the charge, and, where all the furnaces were being damped together, the blast was so adjusted that each furnace received its charge at a definite rate per hour—whilst maintaining the stock at the required level—which enabled all to be ready for taking off together. For the guidance of the frontside foreman, the number of beds of iron which he might expect by the time the coke was well down was also calculated, and if there had been any material shortage in the final cast it would probably have been decided to blow the furnace a little longer to make sure that no iron was left in the hearth.

For the final cast the tap-hole was specially prepared as low as possible and of the greatest area obtainable, usually two or more bars being driven side by side when tapping to ensure a good flush of iron and slag with as little resistance as possible. Every effort was made to remove all trace of fluid material from the hearth, and then the hole was stopped with specially prepared coal clay.

As quickly as possible after the blast was off the "bags" were removed and the tuyeres stopped up tightly with fireclay, and sufficient of this clay was added to completely fill the tuyere and to give a smooth surface covering the joint between the tuyere and the cooler. This surface was then grouted, together with the whole of each tuyere arch, in order that any cracks on cooling could be immediately detected and resurfaced, and all brickwork was carefully pointed by bricklayers.

While this was being done, the downcomer valves, bleeders, and bell were also closed and sealed. Water on tuyeres and coolers was slacked right down, and the furnace was then allowed to stand without further attention, except regular examination for signs of cracks in clay or pointing, which were promptly attended to.

BLOWING-IN

The following briefly describes, step by step, the process followed in a large number of instances, and in every case without exception the furnace quickly dropped into normal working.

Where the stand has been lengthy, and subject to the damping-down having been efficiently performed, the furnace at the time of starting up will be found to be practically cold in the hearth, which will be full of tightly packed coke, probably bound together by solid slag in the interstices. The hearth level may be slightly above normal working height, but not sufficiently so to cause any inconvenience. Ash will also be found in inverse proportion to the success of the precautions taken to prevent air infiltration during the stand.

It was realized that to turn on the blast to a furnace as described would mean that at any tuyere through which the blast could force a passage melting would commence. The molten material, having nowhere to go below the tuyere, would be forced up by the blast into the openings above, until the pressure of blast became insufficient to hold up the weight. Then the slag would begin to run back into the tuyere—a condition which of course would rapidly become worse if the blast were taken off the furnace, and the whole volume of semi-molten material allowed to fill the tuyere, bag, and gooseneck.

The cure for that is to force the blast downwards, and so to provide room for the molten material, while also heating up the hearth to prevent it resolidifying, and to this end the first step was to break away the brickwork at the tap-hole. An opening, roughly 2 ft. square, was made, and through this opening was raked any ash found, whilst the solid coke and slag was chiselled away till a large hollow space, perhaps 3 or 4 ft. in diam., was formed, connecting up to at least two tuyers nearest to the tap-hole.

Whilst this was being done the other tuyeres round the furnace were cleaned out, and any ash raked away. If only cold-blast was available for the blowing-in an endeavor was made to bring hot coke down to both the hearth and the tuyeres, and when this was accomplished all the tuyers were clayed up except the two, or at the most three, tuyers near the tap-hole.

The opening in the furnace at the tap-hole through which the cold material had been raked was

TABLE I.—Details of the Damping-Down and Restarting of Two Blast-Furnaces

Furnace No.:	1.	5.
Condition of lining	Good	Moderate
Size of coke blank	121 tons	37 tons
Details of ore in charge	Nil	10 rounds { Coke, 45 cwt. Ore, 50 " Lime, 11 "
		Filled up with { Coke, 45 cwt. Ore, 55 " Lime, 12 "
Length of stand	175 days	338 days
Furnace	Sealed and isolated	Open to gas from other furnaces
State of material in hearth at close of stand	Clean. Free from ash. Hot	Clean and soft. Free from ash. Cold
Blast on at	9:25 a. m., Dec. 8	6:20 a. m., May 27
Pressure	½ lb. at furnace	1½ lb. at furnace
No. of tuyeres	3 tuyeres	3 tuyeres
Temperature of blast	Practically cold	1500 deg. F.
Gas into main flue	11:10 a. m.	8 a. m.
Hole clayed up first	3:15 to 3:45 p. m.	11 to 11:20 a. m.
Slag to ladle	6:15 p. m. Hot grey slag	12:50 p. m.
First iron on beds	6 a. m., Dec. 9	
Last tuyere opened	11 a. m., Dec. 9	3:15 p. m., May 27
Slag notches opened	4:30 p. m., Dec. 10	10 a. m., May 28
Cast analyses. Silicon, %	Dec. 9: 7.02, 7.34, 9.28, 9.04	May 27: 5.94, 4.40, 4.34
	Dec. 10: 6.80, 5.60, 5.14, 4.36, 3.00, 2.52	May 28: 5.80, 3.86, 4.56, 3.50, 3.74, 3.70
	Dec. 11: 3.76, 2.80, 3.22, 3.48, 3.46, 3.38	May 29: 5.16, 4.32, 5.30, 5.04, 4.32, 4.56
	Dec. 12, 2.78	May 30 3.60

bricked up, leaving a hole 9 in. wide and about 18 in. high. This was left open, and the blast was put on the furnace through the three open tuyeres at a pressure of about 1½ lb. only.

A flame quickly appeared at the tap-hole opening, and this rapidly gained in intensity, bringing down white-hot coke to the opening, which was kept clear whenever there appeared to be a tendency for it to become choked.

After some hours, slag began to blow from the hole and to trickle down the trough; the blast was then taken off, the hole cleared of the hot coke, etc., and the opening stopped up with specially coaly clay prepared for the purpose. This clay was not rammed right back, but the hole was just filled with it, with only sufficient ramming to keep it firm, and through the clay was driven a 2 in. square mild steel bar in about the center of the opening, and the blast again put on the furnace.

As the melting zone in the hearth extended, the tuyeres which had been clayed up were opened out gradually from front to back till all were fully open. After blowing for 1½ hour with a blast pressure of 2 to 3 lb. the hole was pared below the bar and the furnace tapped, any slag being run into the ladle and the iron on to the beds. This was repeated at gradually extending periods as the capacity of the hearth increased, and a hard hole was rarely experienced; it was only after probably 24 hours that the slag notch was opened and slag run over the fall, by which time the furnace was working normally.

Table I. contains details of the damping-down and restarting of two furnaces, which serve to illustrate the results obtained by the above methods. Both furnaces were making sale iron, so no effort was made to reduce the silicon quickly, especially in the case of furnace No. 5, when siliceous iron was urgently required, but had low-silicon iron been required there would have been no difficulty in speeding up the increases of ore.

It is to be observed that within 48 hours No. 1 furnace was in a normal condition, whilst No. 5 furnace was normal within 28 hours of putting the blast on, and in neither case was the slightest trouble experienced.

SUMMARY

Damping-Down

1. The coke blank must be of such a size that it will prevent spongy iron from reaching the melting zone.
2. The furnace should be thoroughly drained of all molten metal or slag at the last tap before shutting down.
3. Air infiltration must be prevented.

Blowing-In

1. Before turning on the blast make room below the tuyeres for the molten material.
2. Get the maximum heat possible to the hearth and tap-hole.
3. Blow up through the tuyeres nearest the tap-hole, opening the other tuyeres gradually as space in the furnace increases.

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*Performance and Costs of Operating Fireless Steam Locomotive in Shuttle Service at a Steel Plant**

The Weirton Steel Company recently installed a Fireless Locomotive† in its blooming mill for use on shuttle work in placing buggies of loaded ingots beside the soaking pits. In only a short period the locomotive has shown that it can handle the work easily and savings of the order of $6,000 a year are shown over the alternate use of a standard steam locomotive.

Before the enlargement of the department, buggies were moved by crane and hand methods after a yard locomotive had left a train at the stripper building but this was inadequate to the new requirements. A 50-ton standard steam locomotive was considered for the work but the Fireless Locomotive was purchased because of advantages claimed and now demonstrated.

*Survey made by A. C. Nielsen Company, engineers, in collaboration with C. H. Hunt, chief engr., Weirton Steel Company, Weirton, W. Va.

†Porter Locomotive Co.

Equipment

The Fireless Steam locomotive is a steam unit but without boiler or firebox, these being replaced by a lagged and jacketed tank. Water in the tank is heated by steam from a stationary boiler plant to full boiler temperature and pressure, and thereafter the unit operates as a standard locomotive until the charge is exhausted. As steam is used by the locomotive the temperature of the water and the pressure of the steam in the tank are gradually reduced, as part of the water turns into steam. When the pressure is below that required for operation, the engine is run back to the stationary boiler plant for another charge.

The unit is a 65,000-lb. 4-wheel locomotive capable of a draw bar pull of 14,520 lb. at 60-lb. effective pressure. It will travel on one charge of steam for aprpoximately 20,500 feet at an average tractive effort of one-quarter of rating. At this plant it

has operated for a full shift on one charge, although two charges are ordinarily given.

This unit was put into service on April 17, 1929, and the alternate considered was a 50-ton standard locomotive of the saddle-tank type.

Hauling Problem

The stripping room is directly in front of the soaking pits and has two tracks, one for empties. Buggies stand at all times on both tracks. Loaded buggies carry six ingot molds each and six buggies carry a heat. The stripping crane removes molds from the first two buggies and places them on empty buggies on the next track. The locomotive then pulls the buggies with stripped ingots alongside the pits and, when unloaded, pushes them onto the storage track. This is done three times for each train. The yard locomotive then brings up another train and removes the empties. Three extra buggies are left on the storage track at all times to take molds.

To protect the locomotive and operators from the heat of the ingots, one buggy with a set of tools is coupled permanently to the locomotive. The track is standard gauge, laid with 100-lb. rail, and is practically level and straight except for a 125′ radius curve between charging plug and working track and a double curve of the same radius where the storage track begins. Trackage is in good condition except where it has been damaged by falling ingots.

These operations are carried on for three shifts daily and 10 trains per shift, averaging 60 buggies per shift. One heat is poured to 36 ingot molds carried on six buggies or one train. An average day's output from the smaller furnaces is 15 heats averaging 152.5 tons. The larger furnaces average 15 heats and 245.6 tons per heat.

This work is done with a locomotive crew consisting of one operator and one hook-up man to handle buggies and throw the switch. No fireman is required.

Full data on gross and net loadings and also on distance for each trip are given in table A. The gross tonnage per train varies from 55.78 for locomotive and protecting buggy to 153.17 or 184.11 when a train of two buggies with ingots is handled. Total mileage in 24 hours is about 31.8 and the net tons hauled are approximately 5971.

Charging Procedure

Since the work is continuous and the locomotive is always on duty, charging is done irregularly and when the work permits, rather than when the pressure in the tank has dropped to any predetermined level. When the last two buggies of a train are set along side the pits there is a wait of 15 minutes, or more if the next train is not ready, and the locomotive is run to the station for a charge. Similar periods are found throughout the day.

The charge may be for 10, 20 or 30 minutes, again governed by the need for locomotive service. Ordinarily two charges are given per shift although the average for seven days covered by Table B was seven in 24 hours.

The boiler plant comprises nine 600-bhp. units carrying a pressure ranging from 185 to 200 lb. gauge or higher, at 70 deg. superheat. The capacity is such that the added load for charging the locomotive does not affect other operations. The plant is located at the lower end of the track.

Charging is done by the operator and hook-up man, connections being made or broken in one or two minutes.

Table B shows total 24-hour charging time to be about 164 minutes or 55 minutes per shift. The table also gives pressures before and after each charge. More work between charges or less frequent charging would be possible if the tank pressure were allowed to run down to a safe minimum, and boosted to full boiler pressure at each charge. The records show one charge made at 60-lb. pressure but an average of 115 lb.

Steam Consumption

In Table B the consumption of steam is stated for each of seven charges made on July 18. These are calculated theoretically from the known capacity of the tank, the average pressures before and after charging, the average pressure and superheat of the boiler source and constants from steam tables. The method followed is to determine the total content of heat in the tank before charging, the total heat after charging, and equating their difference to the heat in the steam used in charging. The second and the third terms both contain the unknown quantity of steam but the equation is easily solved.

The theoretical 24-hour steam consumption is shown to be 4,830 pounds. At a cost per M lb. of $.30, the daily cost for steam is $1.45.

A standard steam locomotive, doing the same work, would probably burn coal of approximately the same price per ton but much less efficiently than in the large stationary boiler plant. There would be added costs covering the wage of a fireman on three shifts and also the upkeep on boiler tubes, grates, injector, etc. Therein lies the economy of the fireless locomotive.

General Advantages of Fireless Locomotive

Probably the greatest advantage of the fireless type, other than in cost, which will be taken up later, is the freedom from smoke in the stripping room and pit house. In both, the cabs of the overhead cranes are directly over the track. A standard locomotive was tried on this work for a few months and working conditions in the crane cabs became almost unbearable. The cranemen are unanimously in favor of the present type of unit.

Another factor in the purchase of this locomotive was that the fireless type was considered least likely to be subjected to calls from other departments. It was necessary to have a locomotive at the stripping shed continuously and the management considered that a fireless type, with only one charging station provided, would be considered as a fixture at the stripping shed. As a matter of fact, it has occasionally been used to shift cars of loaded strip to distances of 1200 to 1500 feet and on full charge has a long radius of operation.

Another advantage is that the fireless locomotive is ready for service at all times. The tank insulation is so effective that the loss of heat over 24 hours is slight, whereas pressure on a standard locomotive goes down rather rapidly if the fireman is not in attendance.

There is also no fuel waste when the locomotive is not used, except for the slight loss mentioned above. This is important in work such as covered in this report.

There is some advantage also in operation, since the equipment is considerably simpler than on a standard locomotive. It can be operated by a regular engineer or by a less experienced man. There is practically nothing about the locomotive to get out of order and down-time for shop work should be a minimum.

Operating Costs
Standard Versus Fireless Type

Table C develops comparative costs of operation for a standard steam locomotive of 50-ton size and the 65,000-lb. Fireless Locomotive. The investments in each are depreciated over a period of 20 years. This is a most conservative life for equipment of this type, particularly for the fireless unit, but is adopted as good accounting practice. Fixed charges for depreciation, average interest at 6% and the items of taxes and insurance amount to daily figures of $6.09 for the standard and 4.67 for the fireless unit.

Daily operating items are for maintenance and repair, lubricant, steam for the fireless and fuel for the standard locomotive, water for the latter and operating labor.

Repairs on the fireless locomotive are expected to run between $200.00 and $300.00 a year. The latter figure is used and is considered to be conservatively high. The standard locomotive has numerous parts subject to regular maintenance such as grates, boiler tubes, injector, etc., and repairs on this type of locomotive have averaged about $3.50 a day for parts and labor. This figure is used, as compared with $1.20 a day for the fireless, based on maximum expectancy.

The steam cost for the fireless locomotive was stated in Table B to be of the order of $1.45 a day. Fuel cost for the standard locomotive in this work is unknown but is estimated as 1½ tons at $2.50 per ton. Coal and ash handling would add a small cost, if known. Water at an assumed rate of $.10 per 1,000 gallons for the amount of steam used by the fireless locomotive would cost $.07. This does not take into account water lost by blowing off, washing or popping or safety valve.

Operating labor is the same for each locomotive except that a fireman is needed only on the standard type. The total daily labor cost for the two locomotives is shown to be $57.12 for the standard and $39.12 for the fireless.

The total of the above costs, based on an estimate of repair expense on the fireless unit and an estimate of fuel for the standard, are $70.78 for the standard and $46.64 for the fireless locomotive. The unit costs are $.0118 per net ton handled with a standard locomotive and $.0078 with the fireless locomotive.

Savings

The differential in daily cost is shown to be approximately $24.14. For the year of 250 days this amounts to $6,035. This is a net annual return of 52% on the first cost of the fireless unit.

The above savings are considered by the management to be conservatively figured, although the unit has been in use for only about two months. The management is well satisfied with the performance to date and considers the fireless unit to be the most economical for this type of work.

(See following tabulations of operating data, costs and savings)

Table A
TONNAGE HAULED, DISTANCES AND WORK DONE

Weights

Locomotive ---------- 32.50 tons
Buggy and Stools ---------- 23.28 "
Ingots per buggy—6 per load weighing 25.4 & 40.90 "
Trains per day—15 each of 152.5 and 245.6 tons of Ingots.

Train Make-Up for Average Schedule

1 Buggy with Stools with loco. for protection.
6 Buggies spotted by yard loco.
Fireless loco. handles 2 buggies at a time.

Trips	Dist.	Trains		Tons	Stops
1	610	Eng. & 1 buggy		55.78	2
2	520	" & 3 "	& ingots	153.17*	1
3	542	" & 3 "		102.34	1
4	505	" & 1 "		55.78	2
5	567	" & 3 "	& ingots	153.17*	1
6	517	" & 3 "		102.34	1
7	590	" & 1 "		55.78	2
8	587	" & 3 "	& ingots	153.17*	1
9	492	" & 3 "		102.34	1
10	582	" & 1 "		55.78	1
	5602 ft.				13

*Tonnage is this for 15 trips and 184.11 for 15 trips.

Summary of Work Done on Typical 6-Car Train of Light Ingots

Rolling friction assumed as 10 lb./ton up to point of braking
Curve friction assumed as 33 lb./ton for 46° curves.
Acceleration calculated as ½ MV^2 and windage neglected.

Straight track—	55.78 T. x 1724 ft. x 10 lb.	
	102.34 T. x 1176 ft. x 10 lb.	
	153.17 T. x 1524 ft. x 10 lb.	(light ingots)
On curves—	55.78 T. x 353 ft. x 33 lb.	
	102 34 T. x 225 ft. x 33 lb.	
Acceleration—	55.78 T. to 3 m.p.h. x 1 times	
	55.78 T. to 5 m.p.h. x 4 times	
	55 78 T. to 10 " x 2 times	
	102.34 T. to 7 " x 4 times	
	153.17 T. to 7 " x 2 times	(light ingots)

Total for 6 buggies—light ingots ---------- 9,704 940 ft.-lb.
" " 6 " —heavy " ----------10 379,011 " "
Total for 15 trains of each tonnage ------- 301,259M " "
Hp-hr. @ 1 980 M ft.-lb. ---------- 152
Miles by locomotive in 24 hr. ---------- 31.8
Net tons hauled—30 heats in 24 hr. ---------- 5,971

Table B
LOG OF CHARGING DATA AND STEAM CONSUMPTION

Records For	Average Pressure Differentials	Charges/24 Hour	Min. on Charge
May 17, 1929	119 lb. to 196 lb.	8	225/24 hr.
18	140 " " 200 "	6	150 "
19	92 " 168	5	105 "
21	126 " 195	7	175 "
22	107 " 167	10	195 "
23	107 " 178	6	145 "
July 18	145 " 225		30/charge
(by charges)	145 " 180		10/ "
	125 " 180		20/ "
	65 " 200	7	25/ "
	75 " 150		20/ "
	135 " 185		15/ "
	100 " 200		30/ "

Total time July 18—150 Min.
Average, all days—164 Min.

Steam Consumption on July 18

1st turn—3 charges—	573 lb.	
	270 "	
	467 "	
2nd turn—1 charge —	1378 "	
3rd turn—3 charges—	840 "	
	395 "	
	907 "	
Total charge & cost	4830 " @ $.30/M lb.	$1.45

NOTE: The above has been calculated from known pressures, tank volumes and steam data from tables for stated pressures and charging steam at 200 lb. and 70 deg. superheat.

Steam Consumption Per Housepower—Hour

From Table A ---- 4830 ÷ 152 ---- 31.8 lb.

Table C

COMPARATIVE COSTS OF OPERATING FIRELESS AND STANDARD STEAM LOCOMOTIVES FOR HANDLING TONNAGE OF TABLE A

	Standard Loco.	Fireless Loco.
Investments—50 & 32.5 ton ratings	$15,000.00	$11,500.00
Assumed life—minimum expectancy	20 yr.	20 yr.
Fixed Charges		
Depreciation	$ 750.00	$ 575.00
Average interest @ 6%	472.50	362.25
Taxes and insurance @ 2%	300.00	230.00
Total per year of 250 days	$ 1,522.50	$ 1,167.25
Daily Operating Costs		
Pro-rate of annual fixed charges	$ 6.09	$ 4.67
Maintenance and repair:		
Standard, average based on yard locos	3.50	
Fireless, estimated $300/yr. ÷ 250 days		1.20
Lubricant—.5 and .4 gal./day @ $.50	.25	.20
Steam—Fireless, from Table C	.....	1.45
Fuel—1½ tons @ $2.50 (approximate)	3.75	.....
Water @ $.10/M gal.*	.07M	
Operating labor:		
Operator—24 man-hr. @ $1.00	24.00	24.00
Hook-up man—24 hr. @ $0.63	15.12	15.12
Fireman—24 hr. @ $0.75	18.00	.....
Total daily costs	$ 70.78	$ 46.64
Unit Costs		
Per mile traveled (31.8 for Fireless)		$ 1.47
Per net ton hauled (5971)	$ .0118	.0078
Savings		
Per day—by difference		$ 24.14
Per year—250 days		6,035.00
Net return on investment		52%
Per net ton hauled		.004

*Estimated same as steam for Fireless, and conservative in view of losses through safety valve, blowing down and washing.

*Specifications for Welding Steel Buildings by Electricity**

General Applications—Definitions—Materials—Apparatus—Permissible Unit Stresses—Workmanship—Qualification of Welders—Proportion of Parts—Protection of Steel.

By FRANK P. McKIBBEN†

Section 1: GENERAL APPLICATION

(a). Arc welding may be substituted for or used in connection with rivets or bolts, or other methods prescribed in the Standard Specifications for Structural Steel for Buildings adopted by the American Institute of Steel Construction as amended to date, for connecting together or assembling the component parts of beams, girders, lintels, trusses, columns, or other structural steel used in building construction.

Section 2: DEFINITIONS

(a). Arc Welding

The process of using the electric arc to join steel parts in the molten, or molten and vapor states, without the application of mechanical pressure or blows.

(b). Arc Weld

A weld in which the welding heat is generated by an electric arc formed between the base metal and the electrode, or between two electrodes, with or without the use of hydrogen or other equivalent gas.

(c). Electrode

A specially prepared metal wire or rod used as a terminal in an electric circuit to produce an intense heat by means of the arc, and which may or may not supply the molten steel required for joining the parts to be welded.

(d). Filler Metal

The metal which is added to a weld by the melting of an electrode or a welding rod.

(e) Weld Metal

The material composing a weld.

(f). Base or Parent Metal

The material to be welded.

(g). Fillet Weld

A weld, at the intersection of two surfaces approximately at right angles to each other, in which the weld metal has a triangular cross-section, its two sides being the original surfaces of the base metals, and its third side the exposed hypothenuse.

The size of a fillet weld is expressed in terms of its length and width, the latter being the dimension of the side of the largest isosceles triangle contained in the cross-section of the weld metal.

(h). Butt Weld

A weld joining the edges of a butt joint in which two members are brought together edge to edge but not necessarily in contact, one surface of each member being in the same or parallel planes.

(i). Continuous Weld

A weld of unbroken continuity used for strength or tightness, or both.

(j). Intermittent Weld

A strength weld consisting of a series of short welds in line, alternating with unwelded spaces.

(k). Tack Weld

A short weld used not for strength but for purposes of assembling only.

Section 3: QUALITY OF MATERIALS

(a). Structural Steel

The steel used in structures covered by these specifications shall be of the grade designated as "Structural Steel for Buildings," as specified by American Society for Testing Materials, Serial No. A9, as amended to date.

(b). Electrodes and Welding Rods

The wire used for electrodes, or the welding rods, shall be commercial mild-steel wire made for this purpose, of uniform homogenous physical structure, and free from irregularities in surface, from hardness, segregation, foreign matter, oxides, pipes, seams, or other defects.

Welding wire made from steel produced by the puddling process shall not be used.

The diameter shall not vary more than 0.003 in. above or below the nominal values.

In the hands of an experienced welder, electrodes and welding rods shall show good welding qualities in flat, vertical, or overhead positions, and shall pass through the welding process without exhibiting any unusual characteristics.

The chemical compositions shall conform to the limits given in Table I for uses specified.

Wire of Grade A shall be used for hand arc welding; and Grade B for automatic machine arc welding.

Section 4: APPARATUS

(a). The arc-welding apparatus shall be of standard design and be the product of a reputable manufacturer.

(b). The welding current shall preferably be direct current supplied by generators driven by electric motors or engines having suitable automatic speed regulation. Whether for use in hand or machine welding, the generators shall be adjustable for

*Reprinted from General Electric Review.
†Consulting Engineer, Black Gap, Pennsylvania.

different current values and shall deliver constant current at suitable voltage for each setting of the regulator.

Section 5: PERMISSIBLE UNIT STRESSES

(a). The welded joints shall be so proportioned that the combined dead and live loads, and impact, if any, shall not cause the stresses therein to exceed the following amounts in pounds per square inch:

Shear on minimum section of weld metal	11,300
Tension of minimum section of weld metal	13,000
Compression of minimum section of weld metal	15,000

(b). The maximum fibre stresses due to bending shall not exceed the values prescribed in paragraph (a) for tension and compression respectively.

(c). The stresses in welded joints due to wind only, and combined stresses due to wind and other loadings, may exceed by 33 1/3 per cent the values prescribed in paragraph (a); provided the section thus obtained is not less than that obtained if the wind force be neglected.

(d). In designing welded connections allowance shall be made for bending stresses due to eccentricity, if any, except that in designing fillet welds no allowance need be made for the bending couple formed by resultant stresses on the two fused sides of the weld.

TABLE I

	Wire, Grade A Per Cent	Wire, Grade B Per Cent
Carbon	0.13 to 0.18	Not over 0.10
Manganese	0.40 to 0.60	0.25 to 0.45
Phosphorus	Not over 0.045	Not over 0.045
Sulphur	Not over 0.045	Not over 0.045
Silicon	Not over 0.06	Trace

Section 6: WORKMANSHIP

(a). The surfaces to be welded shall be reasonably cleaned of loose scale, rust, paint, or other foreign matter by wirebrushing, chipping, or hammering; except that a thin coat of linseed oil need not be removed before welding.

(b). The welding operators shall submit evidence of experience in welding structural steel with the kind of welding to be used on the proposed work, and show ability to make flat, vertical, and overhead welds of uniform quality conforming to the requirements of these specifications.

(c). After being laid, the welds shall be brushed with wire brushes, and shall show uniform sections, smoothness of weld metal, feather edges without overlaps, and freedom from porosity and clinkers. Visual inspection at the edges and ends of fillet-joint and butt-joint welds shall indicate good fusion with and penetration into the base metal.

(d). The arcs for electric welding shall be of proper lengths to produce good welds.

The same electrode may be used with various thicknesses of plate, but thicker plates require heavier currents.

(e). The current values to be used in hand welding are indicated approximately by the figures shown in Table II, which are intended as a guide to the operator who shall select the size of electrode and then adjust the electric current to produce good homogeneous welds of the foregoing characteristics.

TABLE II

Electrode Diameter in Inches	Ampere for Hand Welding	Corresponding Plate Thickness in Inches
1/16	50 to 75	Up to 3/16
3/32	75 to 100	Up to 1/4
1/8	100 to 150	Above 1/8
5/32	150 to 200	Above 1/4
3/16	175 to 225	Above 3/8
1/4	200 to 250	Above 3/8

(f). The current values for machine welding may exceed those specified in paragraph (e), but machine welding shall, if required, meet the same specifications as specified for welders in Section 7.

(g). In assembling and during welding, the component parts of built-up members shall be held by sufficient clamps or other adequate means to keep the parts straight and in close contact.

(h). In welding, precautions shall be taken to minimize "locked-up" stresses and distortion due to heat.

(i). Before welding new steel to old, both shall be free from paint and other foreign matter, except that a thin coat of linseed oil need not be removed.

Section 7: QUALIFICATIONS OF WELDERS

(a). Butt Welds

The welders may be required to weld four sample butt joints each made of two pieces ½ in. by 9 in. by 12 in. to form a piece about 12 in. by 18 in., prepared with double Vee as specified in Section 8, paragraph (f); of these, two sample plates are to be welded in the horizontal or flat position and two in the vertical position with the joint located vertically.

Each sample plate shall be machined so that the joint is reduced to the thickness of the base metal. From each sample plate, standard two-inch tensile-test specimens shall be made and tested in tension, to conform with the American Welding Society standards. The average tensile strength of each group of five sample plates shall not be less than 45,000 lb. per sq. in., and the tensile strength of the lowest in each group shall not be less than 40,000 lb. per sq. in.

(b). Lap Welds

The welders may be required to weld four sample lap joints each made of ½-in. by 6-in. by 8-in. plates clamped one on the other with the 8-in. edges lined up but with the 6-in. edges offset ½ in. A full ½-in. fillet is then to be made along one 6-in. edge in accordance with the specifications presented in Section 8, paragraph (g).

Upon completion of the welds and after cooling, the specimens shall be torn apart and broken by wedging at the unwelded 6-in. edges; and the fractured metal of the specimen broken through the weld shall reasonably show: bright, dense, even-textured, crystalline or fibrous weld metal, irregularly torn and void of iridescent colors; good fusion of weld and base metals; and good penetration into right-angle corner of the fillet.

(c). Fillet Welds

The welders may be required to weld three sample test specimens of the size shown in Fig. 1. In depositing the weld metal, all craters shall be filled to the full cross-section of the fillets. Electrodes of 3/16-in. diameter shall be used. These specimens are to be tested in tension to ascertain the longitu-

dinal shearing value of the ⅜-in. fillet welds, and the fractured specimens shall be examined for penetration into the parent metals and for freedom of gas holes or slag inclusions in the fillets. The three specimens shall show at least an average ultimate longitudinal stress of 38,000 lb. per sq. in. and the lowest in the group shall show at least 34,000 lb. per sq. in. of minimum section of fillet.

Section 8: PROPORTION OF PARTS

(a). Plate Girders

Girders shall preferably be proportioned by their moments of inertia, but where the approximate method of flange design is used the web equivalent may be taken as one-sixth of the web area, provided no holes exist in the web.

The web splices shall consist of a plate on each side of the web.

The stiffeners may be angles or flat bars, welded to the top and bottom flanges and also to the web by continuous or intermittent welds designed to transmit the stresses. The stiffeners at the bearings or other points of concentrated loading shall be fitted to the flanges.

The connection of component parts of girder flanges to each other and of flanges to webs shall be by continuous or intermittent fillet welds designed to transmit the stresses. Intermittent welds shall be not less than one and one-half inches long, spaced in the clear not exceeding 16 times the thickness of the thinnest piece connected, nor more than four inches in the clear.

Plug or slot welds may be used to fasten cover plates to other members.

(b). Beams

Continuous beams and girders designed in accordance with generally accepted engineering principles may be used, provided that welded connections be properly proportioned to resist bending moments to which they are subjected.

When the toe of a seat angle supporting a beam is to be welded to a web or to a column and is not truly formed, but is rounded due to worn rolls or other causes, either a preliminary fillet shall be deposited to fill the open space after which the full fillet required in the design shall be deposited, or the rounded edge of the toe shall be sheared square to receive the full fillet required.

(c). Trusses

For tension or compression members having symmetrical cross-sections, the fillets shall be arranged symmetrically about the axis of the member, or proper allowance shall be made for unsymmetrical distribution.

For members of unsymmetrical cross-section, like angles for example, the lengths of fillets shall be determined by taking moments about the gravity axis of the member.

(d). Columns

Built-up or rolled-steel columns shall contain no material, except filler plates, whether in the body of the column or used as lattice bars or stay plates, less than ¼ in. in thickness.

The ends of columns shall be faced to plane surfaces at right angles to their axis. Column splices, whenever practicable, shall consist of splice plates connected to the columns with proper amounts of fillets. When sections of columns to be spliced are such that splice plates cannot be used, connections may be formed of plates and angles or other shapes designed to distribute the stresses properly. In all cases, column splices shall be so arranged that by bolts or otherwise the various tiers of a column can be accurately aligned before welding, and shall be of sufficient strength to carry the erection stresses.

The fillets connecting component parts of a built-up column may be either continuous or intermittent, and if of the latter type shall be arranged as follows: Continuous fillets extending at each end of the column for a distance equal to the least width of the column; then intermittent fillets one and one-half inches long spaced not exceeding four inches in the clear for the remainder of the column's length.

Lattice bars and tie plates, where used, shall be welded with fillets to secure strengths equal to those of the rivets in lattice bars and tie plates connected by rivets as specified in the Standard Specifications for Structural Steel for Buildings adopted by the American Institute of Steel Construction and as amended to date.

(e). Welding and Bolting

For welding structures, connections of main members carrying live loads producing impact, and connections of members subject to alternate stresses, shall be welded.

For welded structures, component parts of all columns, girders, and trusses shall be welded with fillet welds.

For welded buildings over four stories high, all column splices and all connections of beams and girders to columns—or within three feet thereof—shall be welded.

Unfinished bolts may be used in the shop or field for connections of small structures used for shelters and for connections of secondary members of all structures, such as purlins, girts, door and window framing, lining up bracing, and filling-in beams in floors. In buildings two or more stories high, sufficient bolts shall be used to connect properly all members during erection.

So far as possible all joints shall be designed to eliminate overhead welding, and arranged so that the welds will be in shear or direct compression.

Tension butt welds shall not be used in main truss members, but may be used in secondary members, wind bracing connections, beam and girder connections.

To the calculated lengths of each weld, proper additions shall be made to allow for the crater.

Fillet welds of lengths less than four times their width shall not be figured as part of any connection.

(f). Butt Joints

All portions of members ¼ in. in thickness, or over, to form butt joints shall be beveled with either single Vee or double Vee, or their equivalents.

The steel for single Vee joints shall be beveled not less than 30 deg. on each edge to form an open angle of not less than 60 deg.

The steel for double Vee joints shall be beveled not less than 37½ deg. on each side of each piece to form open angles of not less than 75 deg.

In all single Vee and double Vee butt joints the beveled edges shall have initial free distances of 1/8 to 3/16 in.; and steel 1/4 to 7/16 in. thick shall be welded in one layer, steel ½ to 11/16 in. in two layers, and ¾ to 1 in. in three layers.

All these joints shall be somewhat reinforced but not to exceed 20 per cent for single Vee or 15 per cent for each side of double Vee joints.

(g). Lap Joints

All lap joints in ¼ to 7/16 in. steel shall be fillet welded in one layer, ½ to 11/16 in. in two layers, and ¾ to 1 in. in three layers. The contour of the cross-section of the fillet shall be as near as practicable to a right triangle with equal sides, and with minimum side not less than the prescribed dimension of the cross-section of the fillet.

(h). Drawings

The drawings shall show clearly all welds, including the length and width of all fillets both for shop and field welding.

Section 9: PROTECTION OF STEEL

(a). The structural steel before being welded shall not be painted. If it is to be welded only in the fabricating shop and subsequently erected by bolts or rivets, it shall receive in the shop one coat of acceptable metal protection after shop welding is finished, and one coat after erection. The steel to be field welded shall receive one coat of linseed oil after shop welding is completed; and after being erected and welded it shall receive two coats of acceptable metal protection.

No paint shall be applied to steel surfaces which are to be encased in concrete.

*Report of Electric Welding Committee**

By S. S. WALES†

Discussion

R. M. HUSSEY‡: I want to compliment the Welding Committee on the good work in preparing this report, and in gathering some of the statistics and getting them in shape to appear in the "Iron and Steel Engineer." We have had reports before which have probably had more to do with repair work, but here we touch upon new developments, the fabrication of new parts. And I think this is a start of a very important branch of our activities. I think we should pursue it actively.

The repair of roll necks, couplings, boxes, guides, etc., is pretty much an old story now. There are a lot of good things on the record about that kind of welding work. But we are now coming into the development of new machines, complete buildings and fabrication of other things from rolled steel shapes. That is probably the part of welding work that we could very well give a lot of attention to from now on.

Welded cranes, completely welded overhead cranes, a bridge or two, quite a number of all-welded buildings and electric motors are now outstanding examples of the way in which welding for this kind of work has become established. I don't think we need fear the use of welding for anything that we can use steel for.

We are getting into quite a good many kinds of welding—metal deposit welding, some welding in which the carbon arc is still used extensively, and resistance welding. In the resistance welding there are many names coming up—stitch welding, flash welding and other kinds of welding, which are essentially resistance welding. I think we should take care not to inject or introduce too many names applying to the same kind of welding.

A. M. Candy*: I didn't really expect to say anything this morning, but Mr. Wales' paper has stimulated several ideas in my mind which I would like to mention briefly.

In the first place, some of you may be aware of the fact that at our East Pittsburgh plant and Sharon Works are now using steel at the rate of over 1000 tons a month, most of which is used in replacements of castings which were formerly used in the manufacture of electrical apparatus.

You gentlemen are all interested in the sale of steel; it means our bread and butter. I think the use of rolled steel plates, bars and shapes in place of castings is one line of endeavor where advancement can be made. That may sound a little bit outside of the line of the present-day steel mill, but it seems to me that the time is going to come when the steel companies will produce by welding in some form or another shapes which are not being rolled commercially today, and possibly get into larger sizes than can be economically rolled on the machinery which exists.

The idea is that it would probably pay to tool up and produce large sections by welding, where it may not pay to install rolling mills to get the same results. You may say that the fabricating shops should carry on this work. But shouldn't the steel mills enter into that activity?

Another point Mr. Wales mentioned is the number of welders at some of the steel mill plants. You might be interested to know that whereas today at the East Pittsburgh Works and our Sharon Works we have 300 men doing arc welding work only, a few years ago we had only a small fraction of that number. If we were to include the inspectors of welding, supervisors of welding, and every one really connected with welding work, the number would run up to considerably over 300.

That brings up another point which I wish to make, and that is, if the steel mills are to go into

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*Westinghouse Elec. & Mfg. Co.

the welding work extensively, building up a welding organization is no small job. An effective organization must be formed and the operators properly trained, if the work is to go along satisfactorily.

Mr. Lincoln* of our Company, has had considerable experience in the training of our operators, and it might be that you would like to hear some of the methods we follow at our plant from him.

*Mr. Lincoln is preparing a paper dealing with this subject which will appear in the Iron & Steel Engineer.

*Questionnaire Covering the Organization, Maintenance, Operation of an Electrical Department in a Modern Steel Mill.**

By J. J. BOOTH†

Discussion

R. M. Hussey‡: I have nothing to say in the line of suggestion. The paper was very interesting; the report was very interesting. And Mr. Booth's comments and explanations were very interesting.

I am glad he mentioned the safety work in the safety department, because no matter how good a safety department you may have in the plant, functioning as a separate department, that safety department is very much dependent upon the electrical department and the men in the electrical department, because there are so many pieces of machinery, and particularly the overhead cranes, with which practically every man in the plant is subject to the hazards. For that reason, the safety department as a separate department needs the support of the men in the electrical department.

As Mr. Booth started to explain the questions in the questionnaire, I started to make notes of interesting items. I quit because every item was very important and very interesting. If that questionnaire is given the due and careful consideration by the men in the mill and the data this committee gathers in later is used as it can be used, there will be a lot of useful information for us next year.

A. J. Standing:** It is difficult, in facing a problem of this kind, to know just where to start and where to end. There is so much to say about it and so much of it depends on the peculiar type of organization that there are two or three points I would like to mention in which I take exception to Mr. Booth's statements.

The first point is in the type of the organization, whether it is to be centralized or decentralized. I think the repair shop unquestionably should be centralized. Your organization, of course, will be decentralized. By that I mean that your individual, outside, repair foremen will have their own division headquarters in which they will carry certain spares immediately used in that particular department; but the repairs of almost any nature should be done, I think, in the centralized shop, because then you can better control your repair costs.

In the question of electrical stores, I again take exception to Mr. Booth. I think the electrical stores should be centralized under the electrical department. If anyone in the plant should know how to handle electrical stores, it should be the electrical department and not some general storekeeper or some clerk under the general storekeeper. I think the best control you will have of the spare parts and the spare parts inventory will be through your own organization.

Another point that I want to mention is the two extremes in keeping data. One extreme is very loose operation with practically no data. The other extreme is the keeping of so much detailed cost data that, as has been pointed out, the very keeping of those records becomes cumbersome and costly. Now between those extremes, is a reasonable point where you acquire sufficient data to intelligently operate and at the same time refrain from accumulating a lot of unnecessary, useless records.

One other point that was not touched upon is the fact that in your electrical repair shop, as in any producing shop, the same incentive methods should be applied and can be applied as we have in our Saucon Plant at Bethlehem and most of our Bethlehem repair shops, so that most of the repair work is done under some incentive basis, piecework, contract, or whatever you may call it, which reduces the number of men necessary and assures that your men will get a job done in less than the six months cited by Mr. Booth.

The incentive basis may seem rather difficult to apply to maintenance work. It required detailed time studies on various kinds of shop operations before we applied the system, and at the present time there is about 85 per cent of our work that is on what is known as standard contracts, leaving a comparatively small percentage of specialties.

Regarding the maintenance of cranes I think unquestionably the crane complete should come under the electrical department both electrically and mechanically and including in most cases the crane operator. I think only in that way will you arrive at the best operation from the standpoint of safety, cost and efficiency.

Another point touched was the handling of the

*Presented at Annual Convention, June, 1929.

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**Elec. Supt., Saucon Plant, Bethlehem Steel Co., Bethlehem, Pa.

mechanical parts for cranes. I think this work can be most economically taken care of in your own shop if properly equipped. We can cut our gears and do our mechanical work for cranes at a lower cost than if we had the same work done in the outside shops, and at the same time, we know when we are going to get the job done, which is not always true otherwise.

The question of the meetings is another interesting point. I think the minimum number of meetings should be held to get across what you want your men to know and not have them chasing back and forth to the central department for frequent meetings.

We resort to a week-end general foreman's meeting, touching on operation, past, present and future, and particularly dwelling on the repair work for that week-end shutdown. The other meeting is our safety meeting when we have the permanent safety committeeman who acts as secretary of the committee meeting, and the foremen of the various divisions come in together with the department heads and employees representative.

The Use of Motion Pictures to Illustrate the Generation of Involute Gearing and the Use of Motion Pictures and Polarized Light as a Method of Studying Gear Stresses¶

By W. H. HIMES‡ and R. V. BAUD†

Discussion

L. P. Tyler*: On the question of wear and pitting, I would like to ask whether lubrication has played any part in the investigation, whether he has determined that various film strengths of different types of lubricants would affect the pitting or abrasing.

W. H. Himes‡: Our study along this line has not been taken up with that viewpoint. Of course, there isn't any question but that the lubrication problem is very intimately associated with this gear wear problem. In the work we do with these models, we are simply showing the internal stress as much as possible.

I would like to ask if my co-author, Mr. Baud, has done any study along that line or can throw any light on it.

R. V. Baud†: If you noticed the picture, you would have seen that friction acts in a different manner in the driver than in the teeth of the gear. If you would have lubricants, I think the picture would be the same for it, as well as for the driver.

C. S. Proudfoot**: Does that answer your question?

L. P. Tyler: In part it does. I had an idea there might be in one case a friction gradually wearing away the tooth contour, and in the second case, where the stress on the teeth was beyond a certain limit there would be pitting rather than a gradual wearing away, and that was the point about which I was wondering.

W. H. Himes: Yes, I do, too.

L. P. Tyler: In other words, if there were no lubrication, we will stay there would be a gradual wearing away of the two surfaces. If there is lubrication, but the gear material is stressed beyond the limits, then there likely would be pitting.

W. H. Himes: Yes, in fact, we are pretty sure that pitting is due to excessive localized stresses, causing shear failure just below the surface. I believe we are agreed on that point. The film shows really that there is a low number of teeth on this first set shown where one set of teeth is in contact at a time, carrying full load. That we do have extremely localized stresses is clear from the negative.

S. A. Stage†: I would like to ask Mr. Himes if he would not be able to help us to interpret the polarized light picture by indicating briefly the relative pressures at the point of contact at the approximate depth of the fillets and certain other points of the teeth. It was a little difficult in the picture to get the reasons and to absorb them with the form of chart.

W. H. Himes: I will try to make the set-up

¶Presented at Annual Convention, June 1929.

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†Westinghouse Electric & Manufacturing Company.

more closely to the screen so the play of colors will be more sharply defined.

R. V. Baud: (Slide) The colors in which you observe the increasing stress are as follows: You start with black. You get gray, yellow, orange, red, brown and green. And if you increase the stress further, the colors appear again with the exception of black and gray. Roughly, we can say that the first green is 1600 pounds per square inch, the second 2600 pounds per square inch, the third green 3600 pounds per square inch, and the fourth green 4600 pounds per square inch.

The disadvantage of our black and white movie is that the black and white shades instead of colors. Taking this movie was the first attempt of combining polarized light with motion pictures, and for this purpose we thought we might just as well try the first time with black and white pictures. But what we do contemplate is to beat those movies and make them in actual color.

Now I will explain this picture; the best scheme is to start with this black spot. Then we would go through the complete color order. For instance, I proceed in this fillet. I would go from this black and say the stress that goes through yellow, changing to orange, red and green. Consequently this would be 1600 pounds per square inch. This starts with the second yellow and goes through the second red, brown and second green, so I would say that this fillet was 2600 pounds per square inch.

If you moved to our contact point, we have here the first green, second green, and third green. And if you look at the slide directly you will observe the contact point of the fourth green, indicating a stress of 4600 pounds per square inch.

The trouble with those slides is, if they are exposed to excessive heat for a long time, they lose that coloring, that being spoiled.

Does that answer your question regarding the colors?

L. P. Tyler: Yes, I think it does.

James Farrington*: Have you made any study of alloyed materials?

R. V. Baud: That is the bad part of it. You have to use expensive materials. But we are carrying on an investigation in regard to how much of this stress concentration really should be included in the equation.

For instance, if you have a fillet with a stress concentration of 3.1, you would have to take four amounts of stress concentration into consideration. You would have to include that in your factor. You would have to include that factor of 3.1.

However, if you have ductile material, as Mr. Himes pointed out, your material follows, and the distribution of stress takes place, so that it would not justify the including of stress concentration, the factor 3.1. It would be on the factor of say 1.3 or something of that sort. In other words, just exactly what portion of the concentration factor should be included depends upon the material, but we have been unable so far to give you information on that effect.

If we have ductile material but dynamic conditions, then again we should have the full concentration factor. We have just started to see what really happens in our structures. We are just at the beginning, rather than the middle of the thing.

*Wheeling Steel Corporation, Steubenville, O.

Report of Electrical Development Committee, Association of Iron and Steel Electrical Engineers for 1928-1929†

By WALTER BURR‡

Discussion

Harry Winne*: Mr. Chairman and Gentlemen: I think Mr. Burr has presented a very complete and comprehensive report and one that you can look at and understand and get something out of very easily, without having to spend a whole lot of time digging into it the way one does with some reports.

One thing that particularly impressed me was the comparison of the charts on sheet mills and strip mills. You will note that after 1920 the horsepower installed in sheet mills dropped to a very low value in 1921, but then was climbing very nicely and steadily until 1927, when it suddenly dropped down to a very low value. This sudden drop in the yearly installations of sheet mills is almost coincident with the development of the continuous wide strip mills. Thus, by a study of these charts, one can get the trend, not only in drives, but also in mills.

Mr. Burr mentioned the fabrication of main roll drive motors from rolled steel parts. It may be interesting to you to know that the thing which is limiting the size of fabricated d-c. motors which we can now build is not our ability to fabricate the

†Presented at Annual Convention, June 1929.
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*General Electric Company, Schenectady, N. Y.

frame, but the ability of the steel industry to produce slabs large enough to make the magnet frame. So far, the largest magnet frame we have fabricated from rolled slabs is that for a 5000 h.p.-50 r.p.m. reversing motor. We had to use four slabs for this frame, two in the upper half and two in the lower half, with a circumferential welded seam between the two slabs in each half of the frame.

We have tried several times to get slabs large enough to use for the magnet frame of a single unit 7000 h.p. reversing motor, but to date have been unsuccessful.

It may also interest you to know that we are now fabricating not only the magnet frames, but also the armatures of d-c. machines—not only the smaller sizes, but also the large reversing motors. I think the first motor of any size to use a fabricated armature spider was a 1000 h.p.-40 r.p.m. reversing motor which the General Electric Company built a year or so ago to drive a copper mill. There are now being installed one 7000 h.p. reversing motor, one 3500 h.p. reversing motor, and one 6000 h.p. adjustable speed d-c. motor, all using fabricated armature spiders, and unquestionably this type of construction will be employed extensively from now on.

A somewhat novel drive that has been installed in the past year is that on a reversing Universal slabbing mill at the Wheeling Steel Corporation's Steubenville plant. This mill has separate motors on the horizontal and vertical rolls. These two reversing motors are supplied with power from a common motor generator having three direct current generators operating in parallel on the same bus. This equipment involved some rather nice problems in control, both in balancing the load on the three generators and also in insuring the proper speed ratio between the vertical and horizontal rolls at all points in the speed range. All of these problems were successfully solved and the equipment is working very satisfactorily.

There is a similar, but smaller installation operating on a Universal reversing copper mill.

Fred Schnure*: I was very much impressed by Mr. Burr's paper. It is a very complete report and very interesting.

Mr. Burr's report starts with the motors, the main drives. The curves are very comprehensive. He covers practically the whole field of iron and steel electrification.

One of the features of his report which was very interesting to me and which wasn't presented in very full detail, was that of roller bearings adapted to crane service. There is a question in my mind, and I believe in a good many electrical and mechanical men's minds, regarding the advisability of roller and ball bearing application on various parts of cranes. In fact some cranes have been bought completely roller-bearing equipped, with the exception of the bridge drive wheels. Others have been purchased with the roller bearings on bridge drive wheels and all the rest the sleeve bearing type.

The question arises as to just who is right. I am sure that now no one is willing to go a hundred per cent either one way or the other.

*Elec. Supt., Sparrows Point Plant, Bethlehem Steel Co.

G. E. Stoltz*: This report of Mr. Burr's has been compiled in very fine shape, and I think in presenting this data graphically, one grasps the situation much easier than if he were simply to give us tabulated figures. The thing that impressed me as much as anything was the fact that during last year 58 per cent of the motors—I don't remember whether in horsepower or number—were D.C.

I well remember when we thought that direct current motors were not suitable for rolling mill service. We felt a commutating machine was not a good risk where rolling mill loads varied over a wide range and was subject to dirt-conducting material. After we had installed a number of reversing equipments, we began to realize that we had in the steel industry direct current machines performing the most difficult tasks, under the most difficult conditions and operating successfully.

I think it was then that we began to give up this idea that a commutating machine could not be used in general with entire success on rolling mill applications. Of course, at that time the question came up as to the advantages of the direct current motor where regulation was very important.

Mr. Burr has indicated that plate mills seem to be slower in expanding than any other type of mill, and it is the direct current motor that has affected the tonnage output on plate mills or the installation of new plate mills.

The fact that direct current motors are being used today so successfully and that we can obtain close speed regulation has made the present-day strip mill a success and what it is. Without that type of motor we would not have the large number of strip mills installed during these last few years. Instead of that, we would have more plate mills and more sheet mills.

But I do believe that the application of direct current motors on strip mills will further encroach on what we term the old-style sheet and plate mill.

When motors were first considered for rolling mill drive, we didn't think of the advantages that are so apparent in Mr. Burr's discussion. This Association has had a number of meetings and spent a great deal of time, and very valuable time too, discussing the advantages of electric drive over the steam drive. We always talked about the fact that a mill could be operated cheaper from a power point of view alone than when steam engines were used.

Now that electric drive has been established this question of economy has been given very little consideration. We have selected probably the most expensive and the least efficient method of drive that could be selected, if we consider alone the electrical apparatus. But this apparatus so fits itself, it so dovetails into the requirements of the mill that its efficiency and its cost are of very little consequence.

A mill of that type, the tandem type, could be driven probably more efficiently by bevel gears. The electrical equipment would probably not amount to over one-third, and we would not have the losses of the motor generator set.

That same thing, of course, is true of a reversing blooming mill. We have been accustomed to that type of drive and as far as efficiency of electrical apparatus or drive is concerned, the three-high mill

*Westinghouse Electric & Manufacturing Co.

with continuous running induction motor would be far cheaper and more efficient, but these rather inflexible drives do now permit the operator to accomplish things that would be utterly impossible were it not for the development of this apparatus.

Another significant thing which is brought out by Mr. Burr is the use of synchronous motors. Ten or fifteen years ago, a man would be spreading heresy if he were to appear before this convention and advocate the extensive installation of synchronous motors such as has taken place in recent years. We have overcome our fear of the use of a synchronous motor, and in addition to that, the manufacturers have been adjusting their design and developing motors that more nearly approach the induction motor than those that were available some years ago.

Ten years ago, the synchronous motor would develop about one-fifth of the starting torque per KVA, while today it will do practically 50 per cent. So the design engineers have been busy bringing the synchronous motor design to a point where it more nearly approaches the characteristics of wound rotor induction work. Of course, we have larger power systems where power factor become more important. This is partly responsible for the urge to develop synchronous motors with greater starting characteristics.

*The Application of Pulverized Coal to Metallurgical Furnaces**

By W. O. RENKIN°

Discussion

R. S. Coulter†: Mr. Chairman, I am not at all familiar with the practice at the Lebanon plant. However, I would just like to ask a question of Mr. Renkin, and that is, in his comparisons of tonnages and coal equivalents after the substitution of powdered coal for other fuels, if the furnaces were changed in any way to give the maximum efficiencies, and so forth, that he talks about.

Usually in the changing of a fuel—I know it has been my experience—we take the worst furnace, one that we can't get anything out of, and then we make comparisons with that furnace on a new change that has been made, and give all credit to the new change, which isn't just quite fair.

W. O. Renkin: In the early days powdered coal salesmen simply said that powdered coal could be put in any furnace. "No matter what your furnace is, we will simply put powdered coal on and make some small changes," and that caused a lot of trouble. The results given here are from actual installations.

In the case of open hearth, the furnaces were built for oil, and the changes made in the furnace were the taking out of the checkers, and opening up the neck so that both regenerator chambers opened into the neck at once, in three ports—opened directly. Otherwise, the furnaces were left as they were built for oil.

In the case of heating furnaces today, I do not believe it would be possible—I know it wouldn't be true to say that we could take a furnace fired by hand, or natural gas, or oil, and simply put powdered coal on it.

As you say, it was customary to take the furnace that was going to fall down, and rebuild it. Powdered coal requires a great deal more combustion space than the other fuels. A combustion chamber for a natural gas fired furnace would probably be on a sand hearth type two or three feet long. With powdered fuel it would be eight feet long. The roof will be raised up, where with a natural gas fired side-door heating furnace, the roof might be four feet, or five feet high, it will probably be seven feet on powdered coal.

On a continuous furnace, the old type of furnaces have the roof generally paralleling the skids for half its length, and then a sudden break. With powdered coal you open up that furnace, raise the roof so that the gasses can travel through farther in the furnace, and in the powdered coal fired furnace the roof is up about 18 inches higher on the flat arch roof than on the sprung arch. We have learned that a furnace must be designed for the fuel if you are going to get the maximum output.

R. S. Coulter: That isn't quite the point that I was trying to bring out. What I mean is this, or what I tried to imply was in the comparisons, we should make them with the best oil-fired furnace, or the best producer gas-fired furnace, and I was wondering whether your comparisons were made on that, or made on a comparison of a furnace that was ready to fall down.

W. O. Renkin: No, the particular results I gave were furnaces in operation, and were not the poorest. They were an average condition over a period of time. It would not be a just or safe thing to take a furnace that was ready to fall down, that is using 400 pounds of coal, and say we can do that with

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200 pounds of powdered coal. It wouldn't be fair, because in other plants they have much better furnaces. The figures I have given, are not on the worst condition of furnace, and to show you a worst condition—it is the worst I have run across—an open hearth plant using coal for which they were paying about $5.50 a ton—in the particular case there is a hand-fired gas producer to each furnace—the tonnage is good, and the time is fourteen hours. The report of the president of the company himself—not our side of it at all—was that by changing to the pulverized coal, which he knew how to use and was using in other work, would mean a saving to him of about $2 a ton on the steel over his present practice.

We have propositions that we are working on, where, as against modern gas producers, mechanically stoked, it only runs about 30 cents per ton of steel, but it shows an increase in output, due to shorter time, as well as a reduction in fuel from 550 to 420 pounds of coal, by changing to powdered coal.

R. S. Coulter: Thank you, that answers my question.

F. G. Culter*: We are situated in a district that is fortunate enough to have a surplus of gaseous fuels, so as a result we don't have to even look into the question at the present time of burning powdered coal on heating furnaces.

This subject, of course, has been of great interest to us. In the past we have followed the art of heating with pulverized coal, and I have seen a number of furnaces. The thought that I have on this subject is that the installation should be given proper consideration. I have seen instances of applications of pulverized coal furnaces, where it seemed to me that the installation was not satisfactory due to mistakes in design, and that should be the problem of the powdered coal manufacturers to make sure that they have a proper installation so that the failures will not reflect discredit on the article.

The application of powdered coal is becoming more and more necessary as the price of fuel advances, and it is well that we combustion engineers have the knowledge that such applications are successful.

F. E. Leahy†: There was one statement that Mr. Renkin made that I am rather surpriser a number didn't ask him to open it up a little, that is the application of powdered coal to open hearth furnaces. If you recall they said they took the checker-brick out of the checker-chambers, and I believe got a fuel consumption that was under 500 pounds of coal per ton of steel made. Now, that seems extraordinary in view of what we have been doing with checkers and trying to get more bricks in, and to get better distribution, and more pre-heat. It is a case of going to the opposite direction to get results. I think it would be interesting to hear more about that.

W. O. Renkin: The fuel consumption was 540 pounds over a month's run that I checked. The elimination of the checker was caused by pulverized coal filling the checkers up.

At the plant another speaker spoke about the American Steel Foundries, in Sharon, they overcame the greater part of their troubles by very fine grinding. The latest information I have is that it is running somewhere around 99.01 through 100-mesh, and drying the coal around ½ of 1 per cent. I haven't been able to visit their plant for years, but the man who told me those figures had been there recently. By changing the generator chambers and putting in a simple type of brick arches, the temperature of combustion air, (the secondary air) is about 100 degrees hotter than the same furnace operating with oil. If you figure the 540 pounds as 12,000 b.t.u. coal, it is a very good operation on all cold metal charge.

The checker chambers would fill up with powdered coal somewhere in the neighborhood of about every three weeks. With powdered coal and the simple arches there is no filling up. They are placed far enough apart, so that the fly ash does not build out, consequently the furnace, as soon as these arches become coated, operates at its best capacity rate from then until the time it comes down. You can use a cheaper grade of coal, because you can use slack and screenings. It may be that it is the same coal that you were buying before, but you have the advantage in the difference in cost.

At the plant which I mentioned having visited yesterday, they are paying 6 cents for oil as it is fired. That is all it costs, and they can get coal delivered, slack and screenings, for $1.65 a ton. Six cents for oil at the furnace permits you to spend about $11 for coal as received, and those are the comparisons.

Natural gas as it is priced here and the price you have to pay for it, makes a very expensive fuel, although it is a good fuel.

With reference to Mr. Cutler's remarks about his plant, he is fortunate in having the ideal fuel, by-product coke oven gas, when you have that and have plenty of it, with no sale for it at a fancy price, you have no business considering anything else. There are places where powdered coal will not work out, but there are many places where it will work to advantage.

Mr. Graham: Regarding the precipitation of fly ash in powdered coal, I am interested in that for use in the city here. Are there any additional methods?

W. O. Renkin: I do not know of any additional methods. I think the best example you can get is right here in the city. Across the river is the steel work quarters. By dripping the coal you get combustion in the combustion chamber, and the fly ash does not carry out of the stack to any noticeable extent.

Mr. Graham: What percentage of the ash in the coal is carried through the stack?

W. O. Renkin: No tests have ever been made, because the particular plant mentioned, as well as the A. M. Byers Plant on the South Side have met the smoke inspection laws here for many years, and at other plants—the one I spoke about in the ex-

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tract from the published account—the stacks are clean. Rarely can you see anything even against the blue sky. I really do not know the quantity of ash that is going out, and do not think anyone has ever attempted to measure this at an industrial plant, although there are many of such plants placed right in the residential sections.

H. V. Flagg*: I would like to ask one or two questions. On the velocity of the coal, you mentioned 16,000 feet per minute. Was that on the old west coarse grinding practice, and if so, what velocity will you get on the newer practice?

W. O. Renkin: On the old open hearth furnaces the velocity I gave was running up to 16,000 feet in some installations due to the wet and coarse coal, trying to carry over and prevent the precipitation on the hearth and bath.

At the present time the velocity on open hearth furnaces is fixed by the velocity that will carry the coal far enough to get enough oxygen, which is about 8,000 feet per minute. In the case of heating furnaces the velocity should be 4,000 feet per minute, requiring eight feet of combustion space.

H. V. Flagg: Will the type of coal have any great influence on the preparation of the coal? I have in mind the hard coal from Kentucky, which is a different proposition from the ordinary Pittsburgh coal.

W. O. Renkin: I can hardly say anything for the splint coals and the bone coals around the eastern district except that the cost of preparation is very high. The maintenance is high on that type of coal. In the Malleable Works they use some bone and splint coal from the Kentucky country with about 14,000 b.t.u. It cuts down the capacity of the pulverizer about 50 per cent, which makes it an expensive in preparation.

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*Time Current Control for D. C. Motors**

By D. C. WRIGHT‡

Discussion

A. J. Standing†: Mr. Wright has given us a very interesting paper, describing something new in the line of equipment which we use. There are just a few cases that come in my particular knowledge where this particular type of control would apply.

For example, in well-regulated plants you shut down Saturday night and are down Saturday night and Sunday and Sunday night you start up at six o'clock without any delays. On heavy blooming mills, particularly in the winter time, it is necessary to get your repairmen out sometimes in advance to gradually limber up and go ahead without delay when steel comes down from the pits. That is one case. Another case is in inching bars up to a shear, which is the inching proposition Mr. Wright referred to, oftentimes there is a lost-time in inching a bar up to a shear for cropping.

Another situation is on equipment, as I mentioned yesterday, on a job like a rotary straightener, where the motor must be put across the line because the job must be done regardless of the fact that the machine is stalled. These are conditions which this type of control I think is very largely designed to take care of.

Now, even though the time is late, I think we can profit by some discussion. I may be wrong in this statement, but I believe that the Steel Company of Canada was one of the first purchasers to interest themselves in controls of this sort.

K. W. Raynor*: I think we have felt for some time that a very desirable type of control is one having a combination of time and current, whereby the time is modified by the current, as Mr. Wright has just explained.

Regardless of that, however, there have been and always will be some definite operations which it is desired to do in a definite time. The control which adapts itself to this condition should be selected.

We have in operation the type of control as explained by Mr. Wright, controlling a double drive for the bridge motion of an overhead crane.

Graphic curves, taken simultaneously of the armature current of each of the motors, checked in very exact detail as to current values at corresponding times.

George Baumgarten†: Would not the variation in time, due to the load on a machine where several motions must be synchronized, as on a charging machine, tend to confuse the operator at times when he had a heavier load?

D. C. Wright‡: Most motor applications in steel mills are on series type motors, and on such applications I don't see how any so-called "Definite Time Acceleration" can give a definite time to get the motor up to a fixed definite speed, unless you have only one definite load on the motor. On a

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‡Chief Engr., Electric Controller & Mfg. Co., Cleveland Ohio.

charging machine, I think that you will concede that the load varies considerably.

If you have a light load and the acceleration is set for 2 seconds, for example; then the speed of the series motor, when the last contactor closes is considerably higher than the speed at the end of acceleration on a fully loaded motor. To illustrate; assume a 700 RPM series motor and assume that acceleration is set for 2 seconds regardless of load. The no load speed of this motor would be about 1600 RPM and one fourth load speed would be about 1100 RPM. At the end of acceleration, that is after 2 seconds, we can safely assume that the motor, if fully loaded, will reach a speed of 600 RPM or 10 RPS. The average speed during acceleration would be 5 RPS and since the time was 2 seconds, the motor would have made 10 revolutions by the time the last contactor had closed. Now assume only one-fourth load—the speed at the end of 2 seconds would easily be 900 RPM or 15 RPS, average speed 7½ RPS or the motor would have made 15 revolutions. The light load driven by the motor would have gone 50% further than the heavy load in the same time.

The above being true, I can't see how "Definite Time Control" aids the operator in judging when to operate his various masters. Time of operation of the acceleration switches does not directly control the distance through which the load travels. I don't believe, from my own observation, that an operator watches his master controllers and counts time to gauge when he should throw his various masters on; but instead, he watches his material and judges by its position, when to throw the various switches.

*Report of Electric Tool Committee**

By J. S. MURRAY‡

Discussion

R. B. Ramey†: Having had a little experience in the development of portable electric tools, I may be able to say a few words that will give you some idea of the trend of the development in that field.

The tendency of man ever since the beginning has been to work toward the line of getting some kind of equipment with which to manufacture or build, build homes and do all kinds of work. You might say that the present hand portable tool has developed from the old type of bow and rod, which the Indians used, with which they got rotation for drilling holes, and performing operations of that sort.

Two stages passed through were the air portable tools and the electrical portable tools as the electrical industry developed. We had portable tools first driven by the straight direct current motors and later driven by induction motors as alternating current came into effect. The general tendency, of course, in the development has been to get something that is light in weight in order to make it portable. That is the mission of the tool manufacturer. The highest speed you could get on induction motors, 60 cycle, two poles, is 3600 r. p. m., and on the D.C. machines, while you could get high speeds with compound winding the motors were still very heavy, making the tool rather cumbersome.

Then the universal motor was developed, and you could get high speeds running from 12,000 to 16,000 r.p.m. and by gearing down to the tool speeds which you needed get a portable tool which was light in weight, not bulky, and rather convenient to handle. The universal motor, being a Series motor, is built along the lines of the direct current motor, has the wire winding, armature, commutator, and sliding contacts, all of which are inherent disadvantages, especially when the motor has to be made so small in order to make the units portable. Your spaces for insulation and so forth are rather small.

So the next trend in the development was to introduce the high frequency motor, wherein with the frequency of 180 cycles you could obtain a speed of 10,600 r.p.m. with two poles, getting up somewhere in the range of the speed you get on the universal motor and getting away from the wire windings on the armature, the commutator, brushes and sliding contact, all of which are points requiring greater expense in maintenance. These points being eliminated, you can cut down the maintenance cost.

Another feature is added, speed which is desirable because we have been tending to make these tools so they would give greater production and greater output. The induction motor used in the high-frequency tool you are all familiar with, and it is recognized as a relatively constant speed motor. The speed is pretty well maintained, but on the universal motor with the series characteristics, the speed drops off rapidly in the load. So with the high-frequency motor, about the same size as the universal motor, you can get a much greater horse power output, because the speed is maintained; the horse power being a product of torque and speed, the output will be very much greater.

A member has brought up a question in regard to less power in the high-cycle motor, because the speed was less than in the universal motor at no load. But I believe he overlooked the fact that the speed on the universal motor drops off rapidly under load so in the end, the maximum horse power output is much greater on the high frequency tool because of the maintained speed.

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*Paper presented at Annual Convention of A. I. & S. E. E. in Pittsburgh, Pa., June, 1929.

‡Elec. Engineer, Follansbee Bros., Follansbee, W. Va.
†Black & Decker Company, Towson, Md.

These tools, developed by the portable tool industry, have been developed to take care of practically every application you run across in your field and in all manufacturing fields. While it may be that the smaller sized tools may not fit into your industry, the range is great enough to cover the largest sizes you are using in reaming or running down bolts and nuts.

The means of operating high-frequency tools has been touched on by Mr. Murray, namely frequency changers when you have the alternating source of power. I might say further that if you have direct current it will be necessary to use the generator set driven by direct current motor and giving 180 cycles by direct generation rather than changing. In either case you can get a means of operating these tools.

It may seem that your power cost would be higher with the high-frequency tools than it would be with the universal tools, but I think in general we can find out that there is practically no difference if any, because the motor in the high-frequency tool, the induction motor, has a higher efficiency than the universal motor, which would mean you consume less power for the same output, and at the same time, because of the higher speed being maintained on the high freqency motor, you will do the same amount of work in much shorter time, and therefore, consume less power for the given amount of work.

The subject of grounding, which Mr. Runyon spoke on, is one that I think is very important and the portable tool industry has recognized the feature of safety and has gone to the extent of equipping all tools with the extra wire for grounding. The tendency is also to try to work to 110 volts as a maximum voltage on portable tools, in order to make them just as safe as possible, because we feel any amount of money expended to save a life is well worth while.

R. J. Cook*: I wonder how many gentlemen at this meeting are using Hycycle portable tools in the Steel Industry represented here. It appears that the use of Hycycle tools is almost entirely confined to automobile body building factories although I have heard of some steel fabricating plants that are using Hycycle for reaming.

There is a question in my mind regarding Hycycle drills and how far we can recommend them. For example, the 180 cycle is theoretical, as the speed is approximately 9,800 RPM idle from which we can deduct some slip depending on the type of rotor used on the Hycycle tool.

On the small Universal tools, 1/4, 5/16, etc., we have an approximate idle speed of say 16,000 with a speed loss in a well designed motor of approximately 35 to 40%, or from 16,000 to 9,600. The drop in the Hycycle being at least 8% we have a motor speed of approximately 9,200 RPM under full load. If the Universal tool is over loaded the speed automatically drops quickly while with the Hycycle tool the speed stays constant and the heat increases until it damages the stationary winding which cannot be cooled as efficiently as the revolving Universal motor winding.

Phelan McShane*: I have very little to offer in the way of discussion. I have enjoyed the papers very much, and I am sure they are very instructive. There is one question I would like to ask Mr. Murray.

I believe I understood him to say that they recommended fuses up to 350 volts.

J. S. Murray: No, I was speaking of the National Electric Code. The use of portable devices operating in excess of 300 volts is not recommended.

P. McShane: That is one point I think the committee might investigate rather carefully because in the use of high frequency you very frequently get into voltages in excess of that.

There is one other thought, in connection with Mr. Runyon's paper in regard to fusing. It seems to me that thermal overload protection in the three phases would go a long way to prevent damage to the tools. Of course, I think the switch should be constructed as suggested, so that when the tool was laid down the switch would open, but very frequently the operator may continue to use the tool and force it, so that in that event thermal overload protection should be supplied.

I am wondering whether it is the practice among users to supply a switch ahead of the receptacle. Some switches like the W.K. 10 or similar devices might be used to very good advantage and probably incorporated in the design of the receptacle.

*The Rotor Air Tool Co.

*Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Items of Interest

A new mechanical tubing plant will be constructed at the Warren plant of the Republic Iron and Steel Company. Electrically welded tubing in small sizes will be made from strip steel.

The Bethlehem Steel Corporation will build six new Open Hearth Furnaces at the Sparrows Point, Md., plant. This will increase capacity of the plant about 400,000 tons per year.

The Carnegie Steel Company's Homestead works are now rolling the new 33 and 36 inch beam and girder sections.

The Empire Steel Corporation at Mansfield, Ohio, are enlarging their steel-making capacity by building two new 100-ton Open Hearth Furnaces. New ladle crane, charging machine and other equipment will also be added.

The Tarentum Steel Corporation's $3,000,000 plant is under construction . Plant is expected to be completed within eight months.

The Central Alloy Steel Corporation has authorized that $600,000 be expended for important improvements at both the Massillon and Canton plants.

The Westinghouse Electric & Manufacturing Company announce that they have received a contract for motors for the Main Roll Drives for the Seamless Tube Mills of the National Tube Company at McKeesport, Pa. The contract price is reported to be approximately $275,000.

Republic Iron and Steel Company, of Youngstown, Ohio, are planning an extension to their Open Hearth plant at Warren, Ohio, at a cost of $1,000,000.00.

Richard Brock has been made Chief Engineer and Master Mechanic of the Spang Chalfant plant at Etna, Pa.

Weirton Steel Company at Weirton, W. Va., fortified itself not long ago on coal when it took over a large Hillman property.

The Central Alloy Steel Corporation recently purchased the Interstate Iron and Steel Company, of Chicago, Ill.

Donner Steel Company, of Lackawanna, N. Y., announces the contemplated expenditure of $2,000,000 for finishing mills, details of which are temporarily withheld.

The Tyson Roller Bearing Company, of Canton, Ohio, will soon begin the erection of a new plant to manufacture a type of roller bearing designed by Frank Tyson, who will be Chief Engineer of the new organization.

Minnesota Steel Company, a United States Steel subsidiary, is to enlarge its merchant mill in Duluth.

The rail mill of the Colorado Fuel & Iron Company at Pueblo, has resumed operation in double shift runs after a seasonable shut-down.

Blaw Knox Company of Blawnox, Penna., are reported to be planning to enter the Chicago district in the production of rolls and castings.

Pennsylvania Fabrication Company has been incorporated to take over the property of the former Bollinger-Andrews Construction Company of Verona, Penna. Theodore S. See, for many years associated with the Jones and Laughlin Steel Corporation, will be President and General Manager.

Sharon Tube Company, a new organization which recently purchased the property of Shenango Machine Company, Sharon, Pa., has begun operations at the plant.

Republic Iron and Steel Company plans to light a blast furnace stack at Birmingham, Alabama.

A. H. Bergendahl, New York district manager of the Trumbull Electric Manufacturing Company, died from an operation for appendicitis at the Stuart Circle Hospital, in Richmond, Va., October 3rd.

"Berg," as everyone knew him, had been associated with the Trumbull Company for eighteen years, having represented them in the Cleveland-Pittsburgh district for many years. He was transferred to New York as manager of the New York office territory in the early spring. He was on a business trip with Mr. H. L. Wheeler, and in Richmond had an acute attack of appendicitis. He was getting along nicely when complications set in which he could not resist in his weakened condition.

He was thirty-six years old.

Bergendahl was a man of decided ability and had a very large circle of friends, especially in the Association of Iron and Steel Electrical Engineers.

Albert E. Walden, an active member of the A. I. & S. E. E., died August 26, 1929. Mr. Walden was located in Baltimore and was formerly associated with the Baltimore County Metropolitan District under the County Commissioners of Baltimore County, Md. He was employed as their chief engineer. Mr. Walden enjoyed the respect of the engineering fraternity throughout the United States.

The Clark Controller Company of Cleveland, Ohio, has just let the contract for an addition to their office building, and construction has now been started. This addition to the office space is following closely upon the heels of a recent large addition to the factory building.

A new method of water coagulation which may revolutionize the water purification industry throughout the world has been developed by C. Arthur Brown, Lorain engineer.

During the past nine months Brown has found that iron sulphate can be obtained more cheaply and permits better coagulation and purification of water than the present method of alum mixed with caustic iron.

In recognition of the success of Brown's latest experiment he was recently awarded the Judge E. H. Gary silver medal.

There is no doubt that the Pneuma-Lectric Lubricating System, recently perfected by the Keystone Lubricating Company marks an important development in lubrication in recent years.

This new system claims complete automatic lubrication with positively no attention except the occasional filling of the grease tanks, and it can easily be adapted to machines of all types and designs.

This system was designed to effect economies, both in power savings, actual lubrication bills and in wear on costly machinery. Mills in which it has already been installed report some very striking instances of where this new lubricating development is saving them time and money.

It is completely automatic. Its design is rugged, and the principles on which it operates is extremely simple. In brief, here is the way it operates:

The first step is to determine how often the machine to be lubricated needs a shot of lubricant to work at highest efficiency. Let's say it is found to require lubrication every 30 minutes.

The clock, which is part of the system, is then adjusted so as to make electric contact every 30 minutes. The instant the clock makes contact, an electric motor starts. This motor operates a distributor, through which the correct amount of lubricant is delivered to the bearings.

On various types of machines now equipped, lubricant is forced to the bearings at intervals ranging from once in 45 minutes to once in 4 hours. The clock control can easily be adjusted to operate at intervals of from once in 5 minutes to once in 25 hours.

This system has already been installed in several plants and other installations are under way at the present time.

The hydraulic operator, a new and interesting industrial control device, has been developed by the General Electric Company.

The hydraulic operator takes the place of large alternating, or direct current magnets and solenoids and may also be used to replace air cylinders where quiet and smooth upward thrust is desired through a given distance. It consists of a motor-driven centrifugal oil pump, the impeller of which is mounted in a piston and driven by means of a spline shaft. This arrangement permits the stationary mounting of the motor. The normal position is with the piston at the bottom of the cylinder which is approximately 2/3 full of oil. When energized the motor drives the impeller creating a pressure between bottom of the piston and bottom of the cylinder.

The piston is cast so that the oil is fed to the center of the impeller from both the top and bottom. The oil is forced from the end of the impeller blades through ports to the space below the piston. The pressure tends to move the piston upwards and it will travel the full length of the cylinder providing the load on the ends of the push rod is not too great.

The operators are rated on the stalled thrust basis; that is, the number of pounds they will balance when the motor is running at full speed. The three standard sizes give 200, 300 and 600 pounds push. The speed of operating is slower than that of a solenoid, but is relatively fast. The motors used are small, ¼ to ½ horsepower, and therefore come up to speed very rapidly (in approximately 0.1 of a second). The time required to raise the piston will depend upon the diameter and speed of the impeller, the diameter and length of the cylinder and the load to be lifted. In the largest size without load the piston will start in 0.1 of a second and will move through 6 inches total travel in 0.45 of a second. With 300 pounds or half load it will start in 0.35 of a second and complete travel in 0.85 of a second and with maximum or stalled thrust load, 600 pounds, it will not move at all or very slowly. Due to the stored energy in the revolving parts the downward movement does not start until 0.3 of a second after the motor is de-energized and that is with maximum load and as the oil must be forced back through the revolving impeller blades as dashpot action results and it requires .8 of a second for the total downward travel.

The device can be applied to brakes, clutches, door and window openers, spot welders, pumps and other places now filled by solenoids and air cylinders.

Newton Steel Company has purchased 24 Freyn Design Electric Roll Heaters from Freyn Engineering Company. These electric roll heaters will be used for preheating sheet mill rolls at the new works the Newton Steel Company is building at Monroe, Michigan.

The American Institute of Steel Construction, Inc., 200 Madison avenue, New York, has just issued a handsome 47 page booklet covering the subject of Steel Bridges. Subjects discussed are Beauty, Strength, Permanence, Flexibility, Movability, Economy and the Superiority of the Steel Bridge.

The Bristol Company, Waterbury, Conn., is distributing a new bulletin on the subject of Hot Blast Temperature Control. The bulletin is profusely illustrated and should be in every Fuel Engineer's files. Write C. S. Wadhams, The Bristol Company, Waterbury, Conn., for a copy.

Frank Smith, a popular member of the A. I. & S. E. E., associated with the Otis Elevator Company, at Pittsburgh, has left for Manchuria, China. He will be gone for approximately three months.

The men of East Works of the Middletown Division of the American Rolling Mill established what is believed to be world's safety record for large steel plant up to 5:15 on morning September 11, going forty-seven days and 1,241,823 consecutive manhours without lost time because of an accident.

The Trico Fuse Manufacturing Company, Milwaukee, Wisconsin, makers of Trico fuses and fuse pullers, have found it necessary to move their Chicago office to 549 West Washington boulevard, Room 614, Chicago, Illinois.

The author of the article "Spring End Trucks for Cranes," which appeared in the September issue was Mr. John Minty.

Freyn Engineering Company has been engaged as consultants by the Otis Steel Company in the remodeling of the No. 2 blast furnace plant at the Riverside Works of the Otis Steel Company.

OPEN HEARTH DEPARTMENT FATALITY

The following account of a fatality which occurred in an Open Hearth Department, will be of interest to all steel plant men (National Safety Council news letter):

"I have a recollection that you have asked members of the Council to report on all accidents resulting in the death of employees.

"We had such an accident on June 19, 1929. The facts in connection with which I am passing on to you so that others may have the benefit of our experience. The death came as a result of an explosion in our Open-Hearth Department at our Steel Plant. A mixture of aluminum powder (15#), water 27 gal. and three pints of molasses has been used for spraying the inside of ingot moulds. There were two barrels of this mixture contained in open steel drums, these drums containing the spraying mixture were kept inside of a steel box which had a hinged lid.

"Formerly the mixture was kept in the open steel drums, but on account of the fact that it had caught fire several times, the box had been provided as a means of making it safer. Apparently gas formed within the steel box and from this the explosion came.

"An investigation following the accident has been made and chemists have come to the conclusion that there is not sufficient gas formed from this mixture to cause any trouble if the mixture is kept in open drums.

"We trust that this information will be of benefit to others who may be using aluminum powder for the purpose of spraying ingot moulds."

GULF STATES STEEL COMPANY'S NEW PLATE MILL

To increase the diversity of its products, the Gulf States Steel Company is now preparing to install an electrically driven three high 32" universal plate mill. The mill and its drives embody a number of entirely new features which reflect the modern tendency toward refinement of rolling mill design. The contract for the complete electrical equipment amounting to $250,000 was placed with the Westinghouse Electric & Manufacturing Company. Mr. Warren Worthington, Pittsburgh, is consulting engineer on the mill design and the F. H. McGraw Company, New York, are the construction engineers.

The main drive for the mill consists of a direct connected 4,000 hp., 800 volt, 80/160 rpm. adjustable speed reversing mill type direct current motor receiving power through at 3200 KW. flywheel motor generator consisting of two 1600 KW. 705 rpm. generators, a 4000 hp. 6600 volt induction motor and a 65,000 pound steel plate flywheel. This will be the first three high universal plate mill to have a direct connected heavy duty adjustable speed drive.

The contract for the electrical equipment included the motors and control for all the mill auxiliaries. One of the new features of the auxiliary equipment is the automatic screwdown control for adjusting the setting of the rolls for each pass, by means of which a greater tonnage of more uniform and more accurately rolled thin plates can be produced with less labor than with the conventional manual control. The Gulf States plate mill will be the first mill of its kind to be equipped with automatic screwdown control and the complete installation will be representative of the most advanced mechanical and electrical design.

Marked improvement in the condition of coal mining communities is reported by the Bethlehem Mines Corporation as a result of prize awards to individual miners for cleanliness and general appearance of their houses and streets. At the annual inspection of the mines, which are subsidiary to the Bethlehem Steel Corporation, four cash prizes totaling $50.00 were awarded in each of sixteen mining communities. In making the awards, the condition of the miner's house and grounds to the middle of the street and ten feet to the rear of his lot were taken into account. On this basis 81 miners' houses in the sixteen communities won prizes.

The Illinois Steel Company, a subsidiary of United States Steel Corporation will increase capacity in the Chicago District, 2,500,000 tons annually. New construction work includes four open hearth furnaces, two batteries of by-product coke ovens of 70 ovens each, bloom mill and strip mill at Gary works. At the South works the installation of an additional bar mill will provide an annual capacity of 100,000 tons of alloy steel of all grades and sizes. Estimated cost of complete expansion is close to $150,000,000.

The Illinois Steel Company recently gave one of the large electrical companies the contract for the main roll drives of the new wide flange structural mill of the South Chicago works. The value of the contract is approximately $1,250,000.00.

The equipment will include the first application of the twin motor direct drive in rolling mill practice. In this installation the upper and lower rolls are driven by direct connected individual motors, eliminating the pinions and housings which are required by conventional single motor drives. This is a new departure entirely in rolling mill practices and the installation and operation of this new type mill will be awaited eagerly by the entire Iron and Steel Industry.

The De Laval Steam Turbine Company of Trenton, N. J., builders of geared steam turbines for numerous well known vessels of the American Merchant and Naval Marine, has taken a license to manufacture under the American Bauer-Wach patents. These patents cover the use of exhaust turbines and gears to utilize the exhaust from reciprocating engines, thereby developing and transferring to the same shaft 20% to 25% more power from heat otherwise wasted, as the turbine is more efficient at low pressures, and can use the greater volumes to which the steam expands under high vacuum. The fuel consumption of present existing plants can be reduced from 20% to 25% or an increase of power obtained as high as 25%. This system also has the advantage that the turbine alone can propel the vessel at 60% of full speed if the engine becomes disabled. While the first installation of the Bauer-Wach System was made less than three years ago, it has been successfully applied up to the present time, in over 135 vessels with a total horsepower of over 500,000. Dr. Gustav Bauer, whose name it bears, is the engineer responsible for the machinery of the North German Lloyd steamer "Bremen," holder of all Atlantic records for speed.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

IRON AND STEEL ENGINEER

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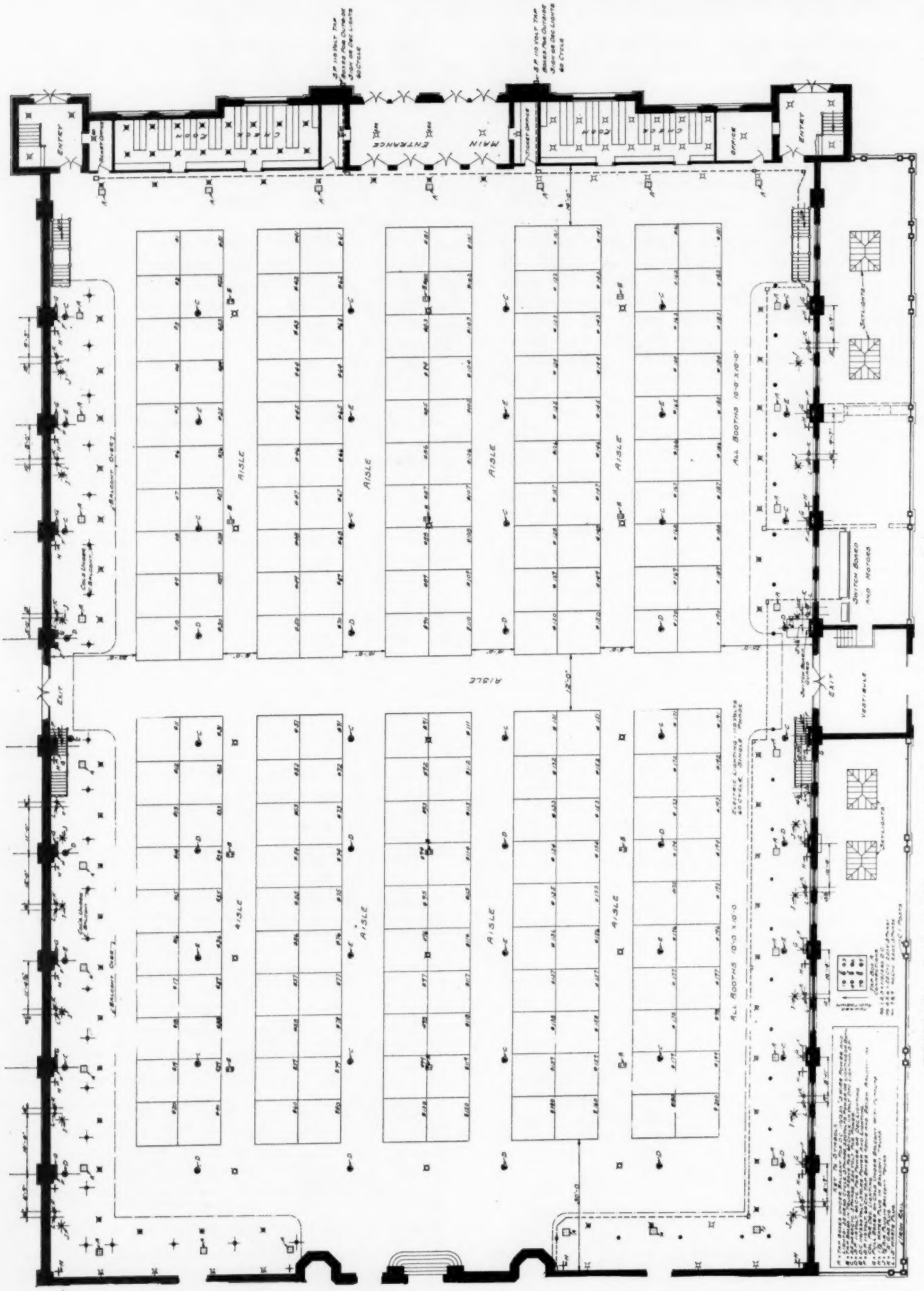
JOHN F. KELLY, Editor.

Sworn to and subscribed before me this 27th day of September, 1929. JOHN G. HOSICK, Notary Public.
(My commission expires March 7, 1933.)



Floor Plan for Iron and Steel Exposition, Buffalo, N. Y., Auditorium, June, 1930. Reservations Accepted.